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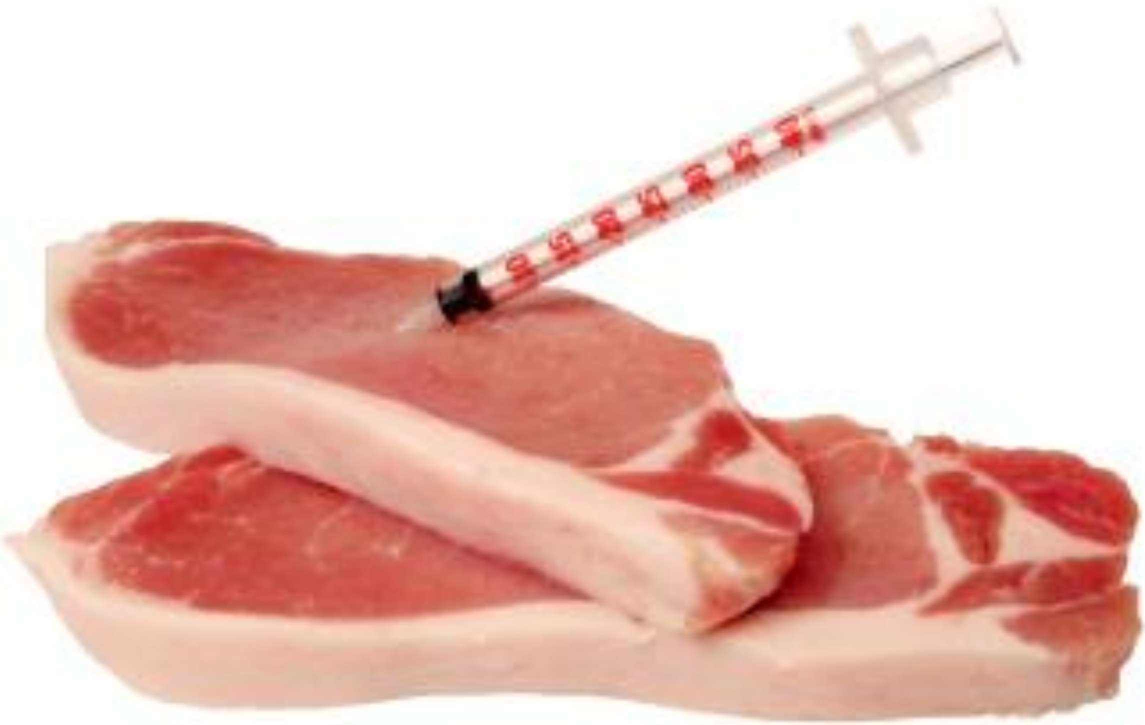
Analysis of factors that influence compliance with the European law regarding terms of antibiotic use in Dutch hog farms



MSc Thesis | Kalina Manolova

Analysis of factors that influence compliance with the European law regarding terms of antibiotic use in Dutch hog farms

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MSc Thesis

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Abstract

Compliance with withdrawal periods of antibiotics in livestock plays essential role in the prevention and reduction of ever more emergent risks related to the presence of antibiotic residues in food product derived from animals. However, there are primary producers who do not comply with the withdrawal periods regarding antibiotic usage which results in unacceptable residue level in food. The current research investigates the factors involved in the compliance behaviour of Dutch hog farmers and it aims to gain insight on the reasons why hog farmers show (non-)compliance. The methods used in this research are desk research (literature study) and modelling by means of decision tree analysis. The effect external factors (like the level of penalties or the number of inspections) that influence compliance behaviour were evaluated in the context of different scenarios. The results showed that in general the regulation on withdrawal periods can have a negative impact on the farm profitability and can be used to explain the occurrence of non-compliance. However, the current level of non-compliance suggests that either these scenarios do not occur so often in the real world or that the frequency of inspection is too low to detect more non-compliant primary producers. In conclusion, possible enforcement strategies can be suggested to either increase the number of inspections or the level of penalty fees. However, these enforcement strategies may not be effective at present due to the fact that residues of authorized veterinary substances are categorized with low or neglected priority risks and non-compliant samples are treated as "accidental mistakes" by the authorities. In addition, because of the low rate of non-compliance it was considered that there are more important factors related to compliance rather than purely extrinsic rewards. The role and guidance of the authorities is seen as a positive external factor that enhances the respect and trust in the system. In addition, farmers participate in the IKB quality schemes where participants recognize the need of fairness and the responsibility to deliver safe and quality food product to the market. This *intrinsic* motivational factor is more important for explaining compliance behaviour than the external ones.

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Acronyms

A 14	Arthritis *hyosynoviae* 14 days before slaughter
A 28	Arthritis *hyosynoviae* 28 days before slaughter
CAC	Codex Alimentarius Commision
COM	Communication from the Commission to the European Parliament and the Council
CVMP	Committee for Medicinal Products for Veterinary Use
DANMAP	Danish Integrated Antimicrobial Resistance Monitoring and Research Programme
E&I	External and internal factors of compliance behaviour
ECR	Efficient Consumer Response
EFSA	European Food Safety Authority
EMEA	European Agency for the Evaluation of Medicinal Products
EMV	Expected Monetary Value
EP 14	Enzootic Pneumonia 14 days before slaughter
EP 28	Enzootic Pneumonia 28 days before slaughter
EU	European Union
FAO	Food and Agriculture Organisation
GFL	General Food Law
IKB	Integral chain management – 'Integrale KetenBeheersing'
ISN	Interessengemeinschaft der Schweinehalter Deutschlands
MARAN	Monitoring of antimicrobial resistance and antibiotic usage in animals in the
N/A	Not applicable
	Netherlands
NIAID	National Institute of Allergy and Infectious Diseases
NRCP	National Residue Control Plan
OECD	Organization of Economic Cooperation and Development
OIE	World Organisation for Animal Health
SRA	Solicitors Regulation Authority
T11	Table of Eleven

Executive summary

Antibiotic resistant bacteria are becoming an important issue facing the human and livestock health worldwide. Even though antibiotics occur naturally in the environment, there are several reasons that have been linked to the spreading of the antibiotic resistant bacteria. One of the main factors is the excessive antibiotic usage in livestock production. In order to prevent and minimize the spread and occurrence of "super bugs", the European Union undertook steps towards reducing the antibiotic usage in livestock, starting from 2006 and empowered by the Regulation (EC) No 1831/2003 with the ban of growth-promoting antibiotics and continued with graduate reduction of antibiotic usage to 50% in Netherlands in 2011 compared to 2009. In order to monitor and prevent excessive antibiotic intake among the population, the European Commission has introduced the maximum residue levels for tissues and edible parts of food producing animals. Therefore, every time when food producing animals are being exposed to intentional administration of antibiotics the reasonable way to prevent exceeded MRLs is by applying the required withdrawal periods before delivering the animals to the slaughterhouse.

The legislative framework laying down the requirements for withdrawal periods and the maximum residue levels allowed in tissues and edible parts of the food produced animals are accordingly, Directive (EC) No 2001/82 and Regulation (EC) No 37/2010. In order these legislative tools to work and their objectives to be accomplished the central element of the effectiveness of these requirements is the farmer's behaviour.

The aim of this research was to gain insight on the factors that influence the compliance behaviour of Dutch pig farmers with the European legislation in terms of antibiotics use. Therefore, the paper dealt with the determent of the key factors influencing the compliance behaviour of hog farmers regarding withdrawal periods. For this reason, firstly an investigation on the usage of antibiotics in food production in the scope of pig meat production, study on relevant swine diseases and elaboration on the term of "withdrawal periods" has been provided. This was done in order to find answers on the first outlined research questions: "How are antibiotics defined?", "Which illnesses occur most frequently at pig farms and which antibiotics are mainly used to treat these diseases?" and "What is a "withdrawal period" and why it is mandatory?". In this manner, these questions provided relevant information on developing disease scenarios which have been further analysed with regards to cost/benefit consideration, seen as one of the external factors influencing compliance behaviour.

Second, study on the legislation framework on antibiotics was performed with description of what are the legal obligations of the primary food producers along with research on the authority practices to observe the enforcement activities and compliance. To high extend this involved capturing the external factors that are related to compliance behaviour and how farmers are entitled to them. By providing study research on the legislation framework it was meant to answer the next set of research questions, as: "What are the basic legal requirements to a pig farmer with respect to antibiotics and with respect to good business practices?",

“Which are the enforcement strategies currently applied and what is the mechanism which national authorities have installed to check on pig farmers?” and “What are the risks/consequences for a pig farmer if one is caught in violation against the law?”.

Third, elaborated social psychology based on Table of Eleven and Theory of Planned Behaviour is performed with intention to further understand the behavioural essence of the subject. In this manner, question as “What is ‘compliance behaviour’ and what is the rate of compliance in terms of antibiotics?” was answered and further conclusion on “Which are the external and internal factors on compliance behaviour?” was done, according to the performed literature study.

Last, the focus on the cost/benefit considerations was investigated in order to analyse in a quantifying way the behaviour of the target group. This was done by using calculation model for production costs in time of disease. With regards to this disease scenarios have been developed and via the Farm model questions as: “What are the net costs and benefits on an average scale for treating hogs?”, “What are the net costs and benefits on an average scale per withdrawal?” and “Is there a countable difference “to comply” or “not to comply?” have been answered. After that via Decision Tree analysis the developed scenarios have been evaluated. Cost/benefit considerations were used to present two sides: from one side a farmer cannot afford to comply with the law and is forced to commit non-compliance or he can afford it but chooses not to comply due to the low probability of inspections. Furthermore, the latter analyses provided insight that regulations regarding withdrawal periods can affect negatively the farmers’ income for which it would enhance non-compliance. The results from the decision tree modelling, based on the EMV (Expected Monetary Value) where this criterion assumes that the farmer aims at profit maximization and he is risk neutral, showed that farmers would violate the law every time when he faces circumstantial events. These circumstantial events have been presented with the development of the disease scenarios that force decision on compliance and non-compliance. Overall, the results showed that if the disease occurs closer to the finishing unit the chances of non-compliance can be certain, no matter how severe the disease might be. For that, the analyses showed that farmer shall violate the law when he faces higher monetary losses if complies. However, in reality neither the antibiotic residues of allowed substances are ranked as priority in the national monitoring programs nor the non-compliant samples (according to most recent EFSA reports) are as high as the model suggested. Therefore, from another point of view, the latter evidence challenged the understanding that compliance behaviour with withdrawal periods could be mainly involved with only higher profitability and for that it was considered that either the developed scenarios are only applicable for disease outbreaks or that there are more important reasons regarding compliance behaviour than seeking monetary benefits or preventing greater losses by non-compliance. In this manner, the severity of the imposed sanction can be also seen as an important external factor. The severity of the sanction varies from high fees through damage of the business image to exclusion of quality assurance program and losing license to produce. However, the severity of the sanctions is highly repressed due to the low inspection frequency which in all means is expected to promote non-compliance. If, however, the inspection frequency is 100% certain, then given the analysed scenario it became evident that both enforcement strategies, severity of sanctions and inspections, must be increased. Yet, these are likely to be not feasible enforcement strategies having in mind that antibiotic residues from Group B1 are not treated as a high, not even middle, priority. Therefore, increasing of fees and inspection cannot be accepted as relevant to the risk category even though antibiotic residues are of a big concern and interest from the side of the public.

The study on the model of Table of Eleven and the Theory of Planned Behaviour brought to the realization that factors influencing compliance behaviour can be divided in two main groups – external and internal factors. External factors were perceived as these factors that shape and create the business environment of the farmer; hence, the legislative requirements that farmers bare as food producers have been studied and described; the standards he must meet when he is part of quality programs; the social norms and peer that are upon farmers in each circle of (in)dependent producers; and ultimately, the objective of cost/benefit analyses of the regulation. While internal factors were seen as these factors that the farmer relies on his own perceptions, such as motivation to keep his business with good reputation, acceptance of the law, respect to the authorities, knowledge of the rules and his own risk attitude. This paper is an attempt to justify that the external factors do not necessary have bigger influence on shaping compliance behaviour but they can apply more pressure in the process of personal evaluation of the given situation, seen in the objective of social peers and the trust in the government and the related competent authorities.

Furthermore, the study on the social psychology of compliance behaviour provided further insight on the internal factors and external factors. The factors that were concluded to be standing out were based on the understanding that people tend to follow the law when they trust and have respect towards the enforcement bodies. In addition, the high competitiveness of the Netherlands influences the motivation of the farmers to provide with high quality of food products and ultimately to be proud with the brand and the image they maintain. In this manner, being a part of quality assurance programs, such as IKB, additionally put social peers and preferences when the majority of farmers show compliance then it is more likely other farmers to reveal the same behaviour. Therefore, it was concluded that clean and proud reputation, perception of fairness, acceptance of the law and respect to the authorities are more important and have major influence for the farmers as compared to monetary prosperity.

Chapter 1

Introduction

1.1. Research Background

Antibiotics are part of the farm management system and are used for prevention and therapy of various bacterial and other infections in food-producing animals through the European Union. Due to the wide availability and the low prices of livestock antibiotics, they are considered as a good economic way to maintain animal health. However, to assure and provide the food supply chain with safe meat products, animals upon slaughter must meet certain criteria because the usage of antimicrobial substances can lead to undesirable and hazardous side effects. According to EFSA these side effects are the promotion of antimicrobial resistance, the potential toxic effects on the cells and tissues of animals, adverse effects due to interactions with other drugs or diseases and, last but not least, allergic phenomena (EFSA, 2012a). The government allows for the individual farmer to maintain a certain economic activity but this has to be done under the laid rules and strict conditions (Elffers et al., 2003). In terms of antibiotics this means the registration of the used antibiotics in the farm, the purpose for antibiotic use, the amount, the strict mandatory withdrawal period in order to avoid antibiotic residues in food, etc. Therefore, to maintain food safety and achieve the set goals, compliance with the acquired rules and norms is required.

From the perspective of food safety, maximum residue limits (MRLs) at the time of slaughter can be determined for veterinary medicines in order to set permissible limits to avoid adverse side effects in humans (Regulation (EC) No 470/2009, Paragraph 2). This, in addition, would require a minimum withdrawal period when antibiotics have been used in food-producing animals. A withdrawal period refers to the time that passes between the last dose administered to the animal and the time when the level of residues in the tissues, milk or eggs are lower than, or equal to, the MRL (Directive (EC) No 2001/82, Article 1(9)). In general, the duration of the withdrawal periods can vary from one type of antibiotic to another. In order the legal levels of antibiotic residues in food-producing animals to be met, food producers need to comply with the related regulations.

According to van der Schraaf (2005) compliance behaviour is ‘the behaviour a regulatee shows to respond to regulatory requirements’. There are two possible types of non-compliance behaviour towards any law: incidental mistakes, whether due to lack of knowledge or extend of acceptance of the law in concern, and intentional non-compliance. Every detected non-compliance is treated by the law with certain sanctions and these can vary whether the non-compliance is wilful or due to error (Elffers et al., 2003). Then, regulatory compliance can be described as the willingness one has to follow and act in accordance with an emerged request, policy, standards or laws. Regulatory compliance is addressed to each party of the food supply chain. Compliance at each level is part of a bigger goal that government and/or public agencies aim to achieve whether it concerns efforts to meet high standards of food safety or more reasonable usage of antibiotics in general. Conversely, non-compliance will lead to undesirable situations and will arouse dissonance. Then, the term of “forced compliance” applies, where the target group is expected not to perform the requested behaviour on their own free will (Eiser, 1986, p. 92). Per se, disregarding the potential financial losses his business might face a farmer is forced to comply with withdrawal periods every time when antibiotics have been used on animals. If, however, he does not comply, then several legal consequences could be imposed on him. Nevertheless, literature suggests that one’s decision to comply or not can be formed not only based one reason alone, such as higher profit, but also the existing attitude toward the regulations in question, the trust and respect he experiences towards authorities, concerns about the image of his business, etc. Hence, if the decision-maker evaluates the situation on his perception of fairness, then it can be expected that non-compliance will arouse dissonance but this would be justified if in result there is adequate extrinsic rewards for the individual (Eiser, 1986, p. 94). Bottom line, extrinsic and intrinsic stimuli of compliance behaviour can be equally related and can influence each other which make understanding and studying compliance behaviour rather broad, providing various sides of investigation.

In 1994, the Dutch Ministry of Justice conducted a study on compliance behaviour which resulted in the creating of “Table of Eleven” (T11). It represents a list of factors meant to be important to compliance with the set rules and norms. T11 is a versatile tool that combines social, psychological and criminal theories based on literature studies addressing compliance behaviour but also on practical experience within the field of law and order. It allows creating compliance profiles of the target group, ‘making it possible to compare enforcement and compliance information’ (Dutch Ministry of Justice, 2004). Hence, the discoveries on compliance behaviour are meant to be an essential part for the ministry to undertake the right actions (priority setting), do things right (effective enforcement), be accountable and self-improve its work according to the most recent findings (Schraaf, 2005). The T11 aims to determine the top two or three ‘key risk factors’ for compliance/enforcement relevant to each regulation (OECD, 2010). Thus, the ‘Table of Eleven’ is not a ready-to-use instrument and it should be adapted to the particular problem of investigation (Elffers et al., 2003). In general, the T11 represents eleven dimensions of compliance (T1-T11) divided in three groups as “Spontaneous compliance dimensions”, “Enforcement dimensions”, “Sanction dimensions”, (see Figure 1).

This was developed jointly by the Ministry of Justice and Erasmus University and derives from academic literature in the areas of social psychology, sociology and criminology, supplemented by the Ministry's practical experiences and viewpoints on law enforcement. The table is in three parts:

- *Spontaneous compliance dimensions*. These are factors that affect the incidence of voluntary compliance - that is, compliance which would occur in the absence of enforcement. They include the level of knowledge and understanding of the rules, the benefits and costs of complying, the level of acceptance of the "reasonableness" of the regulations, general attitudes to compliance by the target group and "informal control", and the possibility of non-compliance being sanctioned by non- government actors.

- *Control dimensions*. This group of factors determines the probability of detection of non-complying behaviour. The probability of detection is directly related to the level of compliance. The factors considered are the probability of third parties revealing non-compliance, the probability of inspection by government officials, the probability of inspection actually uncovering non-compliance and the ability of inspection authorities to target inspections effectively.

- *Sanctions dimensions*. The third group of factors determines the expected value of sanctions for non-compliance, that is, the probability of a sanction being imposed where non-compliance is detected and the severity and type of likely sanctions.

Figure 1: Three groups of dimensions on compliance behaviour in 'Table of Eleven' (OECD, 2010)

1.2. Problem Definition

There are hog farmers who do not comply with the withdrawal periods. This may result in unacceptable residue concentration which can compromise food processing and ultimately the consumer's health. In addition, studies on behaviour under regulatory law are scarce and far less studied in comparison with behaviour under criminal law (Elffers et al., 2003). While the study of T11 has managed to gain consistent knowledge on compliance behaviour, to isolate and systematically present the reasons that can influence it and predict certain compliance profiles, the T11 is not a ready-to-use instrument and should be adapted to the particular problem of investigation (Elffers et al., 2003). Thereof, the key critical factors for this target group (hog farmers) are not yet established and supported with a scientific background regarding withdrawal periods. It is reported that almost 90% of all labor on Dutch farms is maintained by the owner and his family (Statistics Netherlands, 2000). Then, the choice between different alternatives depends on the owner himself, on his perceptions and ways to evaluate the given situation. Overall, every individual evaluates the situation and can make a choice for himself whether to follow rules or neglect them. Therefore, realising the sound rules and reasons of both, compliance and non-compliance, would help to motivate and model sufficient enforcement strategies. Therefore, the aim of this research is to gain insight on the factors influencing the compliance behaviour in terms of antibiotic use in primary pig production.

1.3. Research Objective

The aim of this research is to gain insight on the factors that influence the compliance behaviour of Dutch pig farmers with the European legislation in terms of antibiotics use.

In this paper, three main general objectives of compliance behaviour were investigated – the legal requirements and necessity of compliance, the economic pros and cons of compliance by focusing on the cost/benefit considerations and decision tree modelling, and the reliance of the social psychology to better understand the inner triggers of compliance behaviour of the target group. Attention was paid to determine the sound factors that play a role in the compliance behaviour of the target group. The set "menu" of factors was analysed under different management scenarios and discussed to explain better the compliance behaviour of hog farmers in terms of withdrawal periods and possible enforcement strategies, if needed. The objectives of the economic analysis aim at developing management scenarios consider which impose decision choices and opportunities of compliance and non-compliance. It was considered, that the risk of antibiotic residues (hence, non-compliance) arises when the animals become sick at the end of the production cycle; hence, few weeks before transportation to the slaughter house. The longer the oldest slaughter pigs stay in the farm the more overweight they will get which might result in higher production costs. From one hand, this can lead to serious welfare problems and in addition can reflect on the net profit per delivered pig depending on the feed efficiency of the infected animal, the mortality rate, type of intervention, the weekly price of pig carcass, the carcass quality discount, etc. All these uncertain events (external factors) are seen as opportunistic enhancers of non-compliance when decision is based only on higher monetary expectancies.

1.4. Research Questions

The key research question is:

Which are the factors that determine compliance behaviour of the pig farmers in terms of antibiotics use in the European Union?

To be able to answer the key question, several research sub questions are formulated:

Antibiotic residues in food

1. How are antibiotics defined?
2. Which illnesses occur most frequently at pig farms and which antibiotics are mainly used to treat these diseases?
3. What is a "withdrawal period" and why is it mandatory?

Food Law, Compliance behaviour and Overview of the key factors

4. What are the basic legal requirements to a pig farmer with respect to antibiotics and with respect to good business practices?
5. Which are the enforcement strategies currently applied and what is the mechanism which national authorities have installed to check on pig farmers?
6. What are the risks/consequences for a pig farmer if one is caught in violation against the law?
7. What is 'compliance behaviour' and what is the rate of compliance in terms of antibiotics?
8. Which are the external[1] and internal[2] factors on compliance behaviour?

Economics

9. What are the net costs and benefits on an average scale for treating hogs?
10. What are the net costs and benefits on an average scale per withdrawal?
11. Is there a countable difference "to comply" or "not to comply"? Or what are the costs and benefits "to comply" or "not to comply"?
12. How do personal risk profiles and social variables effect the actual decision that is made?

1.5. Material and Methods

In order to answer the research questions, several sources of information are used.

In this research, firstly an investigation on the usage of antibiotics in food production in the scope of pig meat production, study on relevant swine diseases and elaboration on the term of "withdrawal periods" has been provided. Second, study on the legislation framework on antibiotics is laid down with a description of what are the legal obligations of the primary food producers along with research on the authority practices to observe the enforcement activities and compliance. Third, elaborated social psychology study on compliance behaviour of Dutch hog farmers in terms of antibiotics is performed with intention to further understand the behavioural essence of the subject. For all this purpose, a literature study was carried out to answer the given research questions. The scientific literature is widely available through the Wageningen UR digital library. Key words, for example, 'antibiotic resistance', 'antibiotics in livestock/pigs', 'swine diseases', 'compliance behaviour', 'theory of planned behaviour', 'risk profiles', etc., were used when searching through the web sources like 'Google', 'Scopus' and others. T11 was used

[1] External factors would be considered as those factors for which the farmer is not in power to influence or to change unless he does not change his current practices: such as sanctions, number of inspections, third party reporting, social influence and peers, etc.

[2] Internal factors are considered as those factors for which the farmer relies on his own perception such as: acceptance of the law, motivation, image attitude of his farm, risk perception, etc.

as a starting and reference point to see whether the list of factors is complete and how it can be improved in this specific case. Thereof, an investigation of the key critical factors would suggest that some will be more elaborated while others would be dismissed or be neglected. In addition, via the website of the European Commission (www.eur-lex.nl), all European legislation is accessible to the public. Data from EUROSTAT and other relevant data was gathered and used as input for the economic analysis. Last, focus on the cost/benefit considerations was done to analyse in a quantifying way the behaviour of the target group. This was done by:

I) Conceptual model for compliance with withdrawal periods in hog production

The aim of the conceptual model (Figure 2) is to provide insight into the decision-making process and present a network of the relevant economic and psychological factors concerning compliance with withdrawal periods after administration of antibiotics in Dutch hog production.

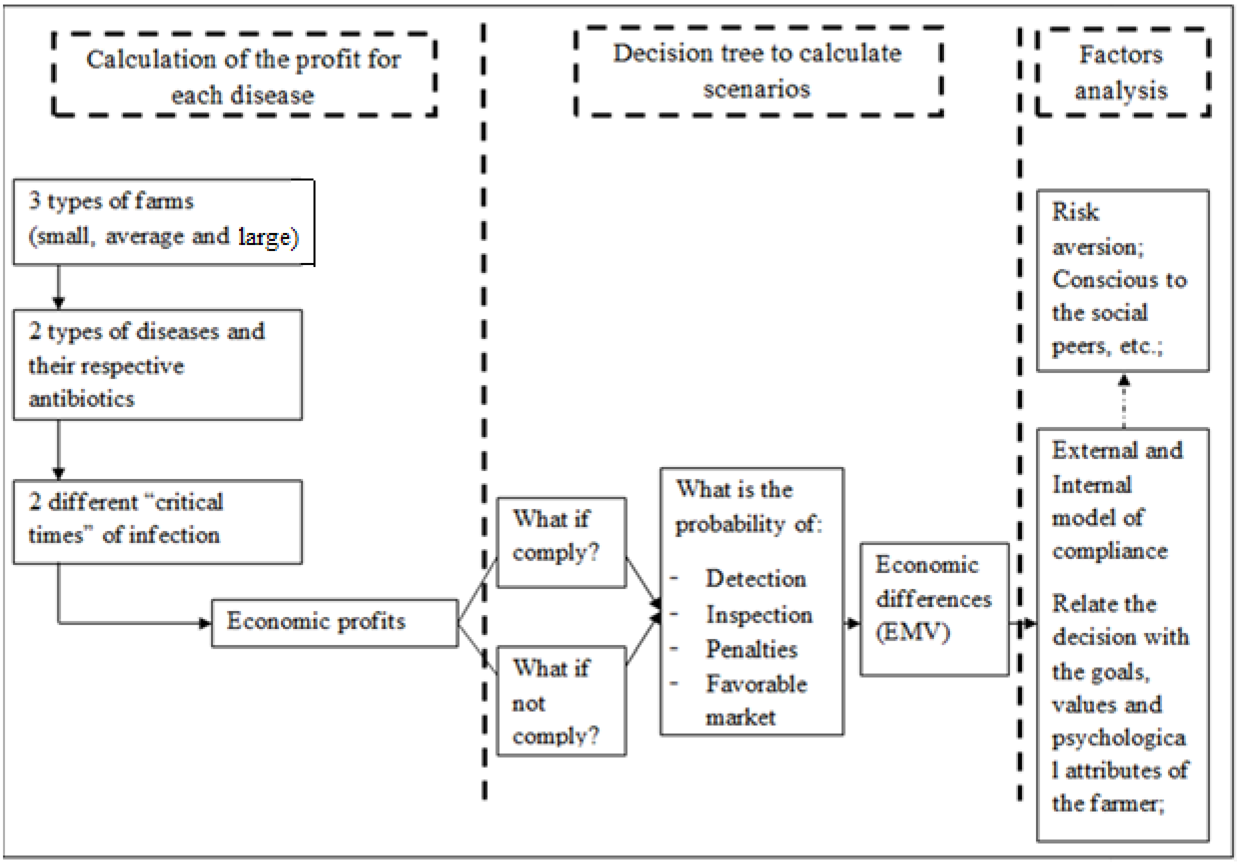


Figure 2: Conceptual model regarding compliance with withdrawal periods

II) Calculation model for production costs in times of diseases

To provide insight into the main determining factors on (non-)compliance, a deterministic spread sheet model was developed. Via this model the production costs, average gross revenues and average net profit on one year base were calculated, for three main scenarios; 1) baseline – no diseases; 2) severe disease; 3) mild disease. It is assumed that the disease will occur only in one house department. It is further accepted that one house department represents a whole batch, since the production practices are based on all-in/all-out (AIAO) principle. Therefore, decisions concern the whole department, thereon, the whole delivery batch. The scenarios were calculated for three different size farms: small (900 pigs in total), average (1500 pigs in total) and large (2000 pigs in total). Each farm has three house departments where the total of the animals are evenly separated. The calculated annual Net Profit per department of the baseline scenario is used as a reference point. Hence, the Δ Annual Net Profit per department was considered in calculating the outcomes of each decision choice in regards with the scenarios; hence, a relative profit compared to the baseline, is used as an input in the decision tree analysis.

III) Decision tree to evaluate different scenarios

A decision tree (Figure 3) is a diagram of a risk decision which takes into consideration multiple alternatives (decision choices). It is used to gage a risk impact of each potential decision or series of decisions to make a determination. When the decision tree and the information within are reviewed then decision analysis can be performed. The nature of the decision tree allows the consideration of decisions, probabilities and various outcomes and also the comparison of decision paths. This ability to follow series of decisions and establish probabilities and impacts of each decision makes decision analysis suitable tool for this thesis in order to see the "complete picture". Therefore, decision tree analyses were used to evaluate the economic differences mainly between compliance and non-compliance and the possible most favourable decision. Expected monetary value (EMV) is the criterion for making a decision that takes into account both possible outcomes for each decision alternative and the probability that each outcome will occur, or in other words it is the weighted average of probable outcomes using the same payoffs and probabilities an infinite number of times. The probability of inspections, probability of detection, and probability of disease spread are taken into account for each decision choice according to the certain scenario. Based on the higher EMV the ultimate decision will come along. However, since it is known that taking a decision is an individual process that presents other choices which might not explicitly based on rational economic benefits, risk profiles were also taken into consideration.

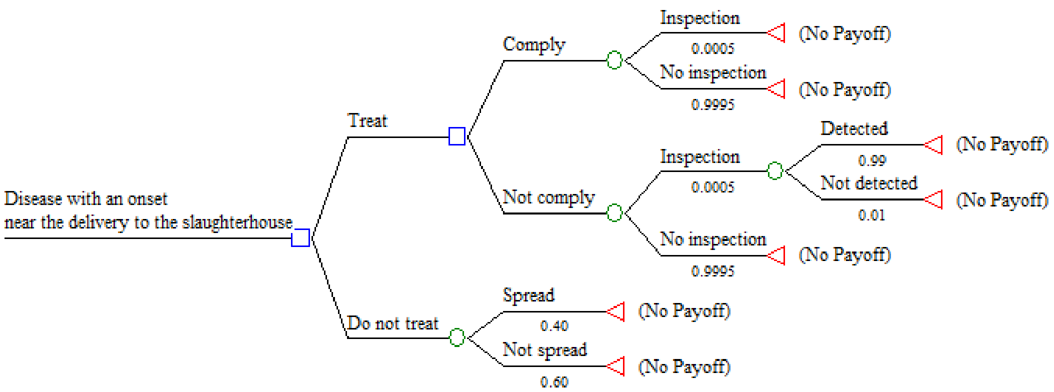
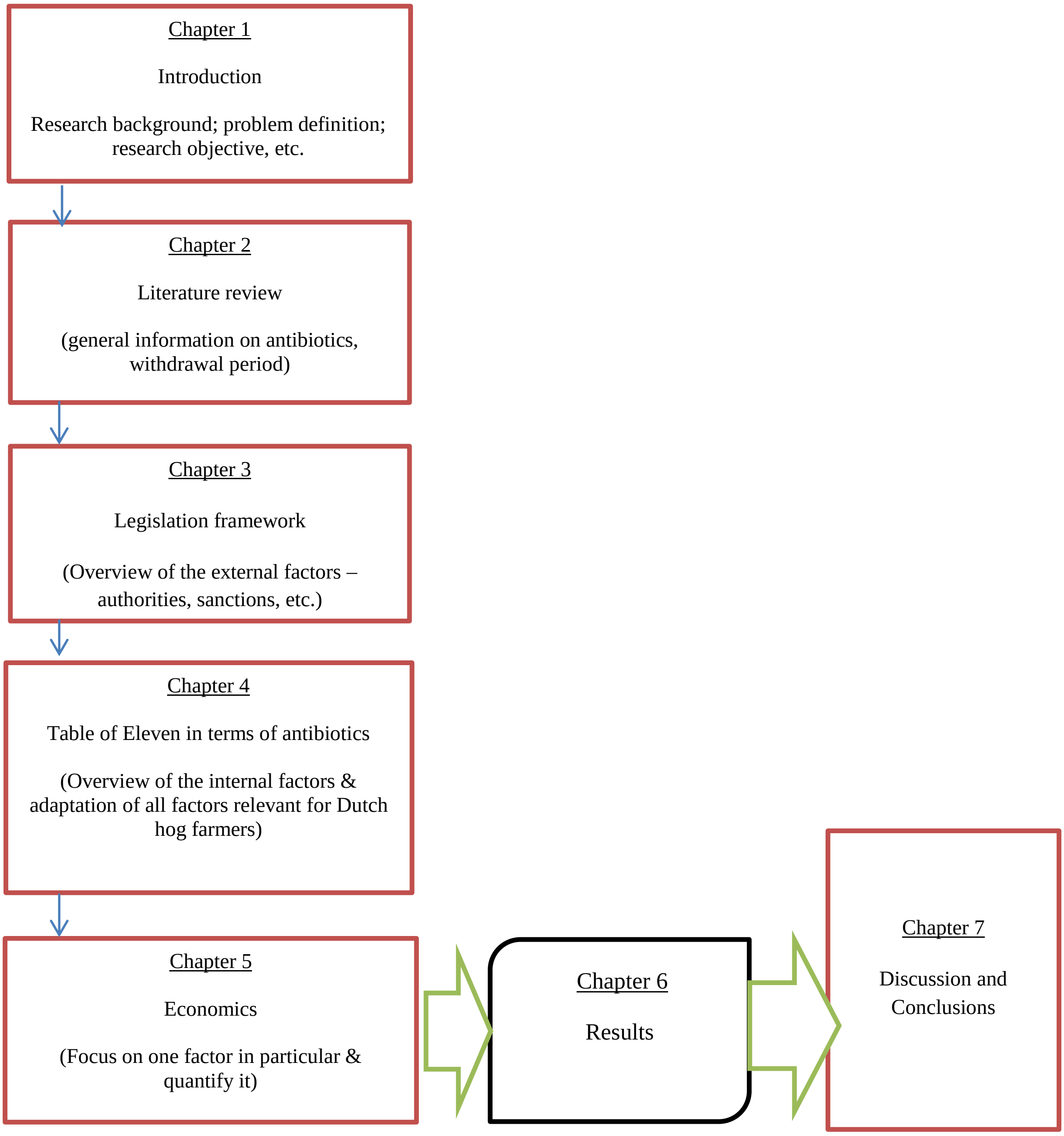


Figure 3: Example of a Decision Tree without specifically referred scenario and payoffs

1.6. Research Framework



CHAPTER 2

Literature Review

In this chapter information on the use and importance of antibiotics in livestock can be found. There is also a brief history and development on antibiotics in the European Union and the critical side-effect that they bear along. Topics, like what are antibiotics, how and when they are introduced in farm management, are discussed. An investigation, on what are the most common diseases that occur in hogs, has been done. In this chapter, an elaborated investigation of the two most common diseases which were used in scenario analyses in Chapter 5 was done. Characteristics of the most used antibiotics are also present in this chapter. Definitions of Maximum Residue Limits and withdrawal period are given as well in order to build up the background of this thesis.

2.1. Antibiotics in food producing animals

Antibiotics are specific antimicrobial substances that have the potency to kill, or inhibit the growth of, microorganisms, including both bacteria and fungi (Holden et al., 2002). They are not effective against viruses even though often the symptoms are similar to bacterial infections (FDA, 2007). The reason why antibiotics are not effective against viral infections is because of the differences in the specific structures and characteristics between living microorganisms and viruses. In addition, antibiotics are also used to treat protozoa or worm infections but often in these particular cases antibiotics are reported to be toxic also for the host since protozoa are microorganisms living “on the back” of their host (Hornby, 2011). Nevertheless, antibiotics are considered to be one of the best and essential treating ways when infection occurs in the human or animal body, especially when the immune system cannot defeat the illness on its own. Yet, over the years, doctors and vets are getting more and more cautious in prescribing antibiotics.

The increasing concern about the usage of antibiotics is the emergence of antibiotic-resistant bacteria (EFSA, 2012a). The definition of antibiotic-resistance, given by EFSA, refers to the ability of micro-organisms to withstand antimicrobial treatments (EFSA, 2012a). Antimicrobial resistance occurs naturally in bacteria to protect themselves by their own metabolic-product (natural antibiotics) while trying to kill other microorganisms that are competing for limited nutrients (Martinez et al., 2009). As antibiotics have been introduced in 1940s and the antimicrobial usage has been increasing since then, so did the antibiotic resistance (Tenover, 2006). Currently, estimations show that more than 70% of the bacteria responsible for the cause of hospital-acquired infections are apparently resistant to at least one of the antibiotics used for the treatment of the infection (Purdom, 2007). Therefore, a patient affected with antimicrobial-resistant bacteria is more likely to have prolonged and complicated treatment for what the chance of dying from an infection is increased (NIAID, 2006). The European Commission reported that there are approximately 25,000 human deaths due to drug-resistant bacteria, that is translated into extra healthcare costs and productivity losses of at least EUR 1.5 billion annually (COM, 2011). In order to combat this negative antibiotics' impact, the European Union put efforts in creating an antibiotics-resistance strategy and regulation plans to strengthen the rules in terms of antibiotic usage in animal farming.

Generally, antibiotics in veterinary medicine are prescribed to treat and prevent infections but also they can be used for non-therapeutic purposes, e.g. disinfectants, preservatives, and food and feed additives (COM, 2011). The term 'nontherapeutic use' defines the drug as a feed or water additive administered to healthy animals when any clinical signs of disease are not evident (Becker, 2010). Thus, there are antibiotics for therapeutic and non-therapeutic (prophylaxis) use:

- **Antibiotics for therapeutic use** – to treat the disease in usually high doses for a relatively short period of time. Often, if a few animals are found to be sick, the whole herd would be treated so the spreading of the disease to be contended as much as possible. Therefore, 'not always there is a clear distinction between treatment and prevention' (Turner, 2011).
- **Antibiotics for prophylaxis** – to prevent infections in the herd when the susceptibility in animals rises, e.g. changing of the seasons, after weaning, etc. (Becker, 2010). This is done by adding antibiotics in the feed or drinking water in low, sub-therapeutic doses for a long period of time. In The Netherlands an average hog pig lives ap. 6 months. During 35-37 days of its life, it obtains antibiotics, which results in a total exposure to daily doses of antibiotics, or 18-19% of its lifetime (MARAN, 2008).

Before January 2006, in the European Union, low doses of antibiotics were permitted to be used as 'growth promoters' in animal feed. From 2006 onwards, the EU banned the use of 'growth promotion' antibiotics (Regulation (EC) No 1831/2003, Article 11). This ban is part of the antimicrobial-resistance strategy to combat and/or slow down the emergence of drug resistant bacteria in the microbial flora of farm animals and to preserve the effectiveness of important human antibiotics (Cogliani et al., 2011). In general, the primary cause of drug resistant bacteria is considered to be the misuse of antibiotics in human medicine (Barton, 2000). Though, some types of resistant bacteria (e.g. MRSA) originate from "the animal farm" which makes the overuse of antibiotics in animals to be a contributing factor to the issue (Graveland et al., 2010). Further, the veto on the 'growth promoters' required expected lowering of the amount of the overall usage of antimicrobial substances in the European farm animal production. The ban on 'growth promotion' antibiotics did not have major consequences on the animal health and indeed some types of antibiotic resistance were substantially reduced (Aarestrup et al., 2001). In the first couple of years after the ban, an increase in the sales of therapeutic antibiotics had been filed, e.g. in Denmark by 49-70% between 1999 and 2001 (DANMAP, 2001) this might be explained by several factors (Turner, 2011):

- Some forbidden growth enhancers might be still used for prevention of diseases, e.g. tylosin;

- The same refers to antibiotics being banned as growth enhancers but are still used as coccidiostats (drugs used to control parasite coccidia infection), e.g. monensin and salinomycin;
- Although the ban did not have a major consequence on animals health this does not mean that the diseases did not increase which might require more antibiotics for treatment;
- Sometimes there is no clear distinction between 'treatment' and 'prevention';

In 1999, Dutch officials integrated a system, called MARAN, to monitor antibiotic use in food producing animals (MARAN, 2012). One year after the official ban of 'growth-promoters' the Netherlands indicated the highest sales of antibiotics in 2007 (Figure 4) which had driven the Dutch government to mandate a policy objective of 50% reduction in antibiotic usage in the next three years (Cogliani et al., 2011). The most recent report on this subject states that the goal of 50% reduction of antibiotics in livestock has been already achieve in 2012 (SDA, 2013).

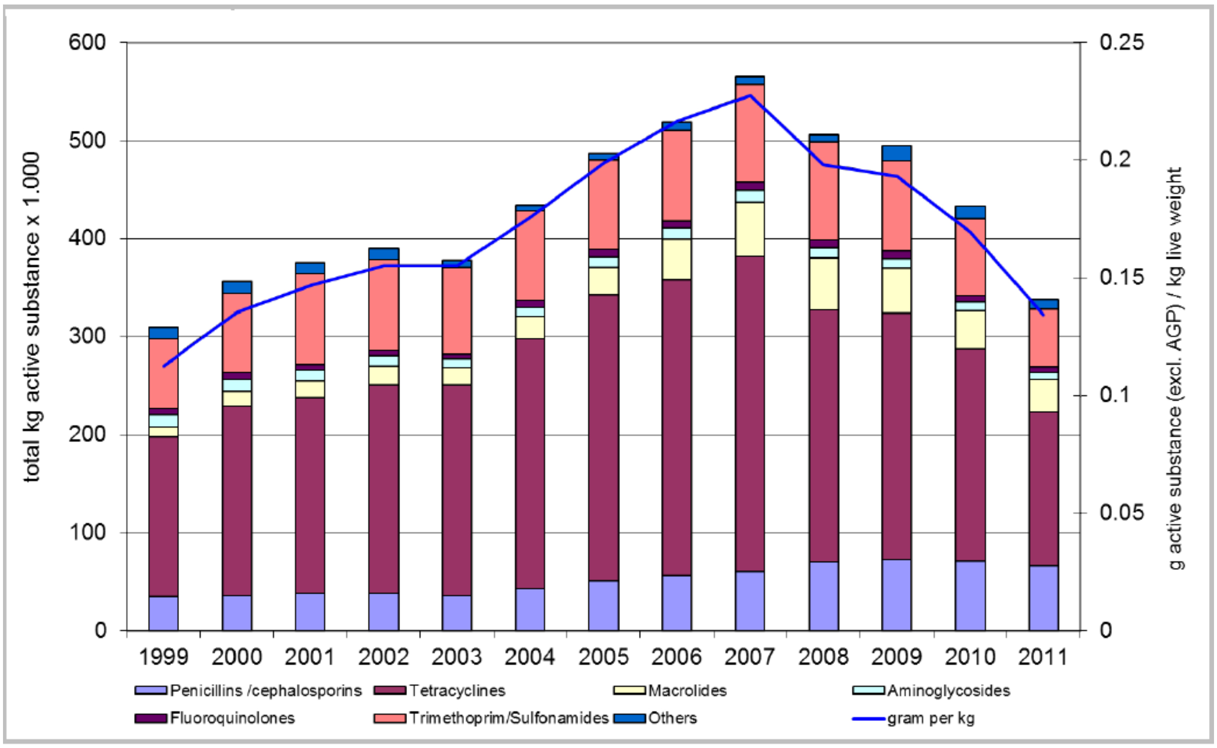


Figure 4: The trend in the total sales of therapeutic antibiotics from 1999-2011, also expressed in grams of active substance per kg of live weight (MARAN, 2012).

In order to estimate which are the most common illnesses that occur in a pig farm data from MARAN (2012) that represent the average use of antibiotics in fattening pigs was used, see Figure 5. This figure indicates the most common antibiotics used for therapeutic purposes. This information was considered useful to determine which illnesses are most common in hog pig farms. Therefore, by observing which are the most used antibiotics in Dutch hog farms, a conclusion based on this information and elaborated literature study on swine diseases is expected to yield the selection of two most common diseases in finishing pigs.

As can be seen in Figure 5, Tetracyclines are most widely used in Dutch pig farms. Tetracycline antibiotics are being used in human and animal medicine since 1945 as therapeutics, prophylaxis and as growth enhancers (Michalova et al., 2004). Contradictory, tetracyclines still could be used in sub-therapeutic dose in feed to promote growth efficiency in fattening pigs even though this would be a violation of the law (Regulation (EC) No 1831/2003, Article 11). Again, there is possibility of misinterpretation to the definition of 'prophylaxis usage' even though they are available only on veterinary prescription (EMEA, 1999).

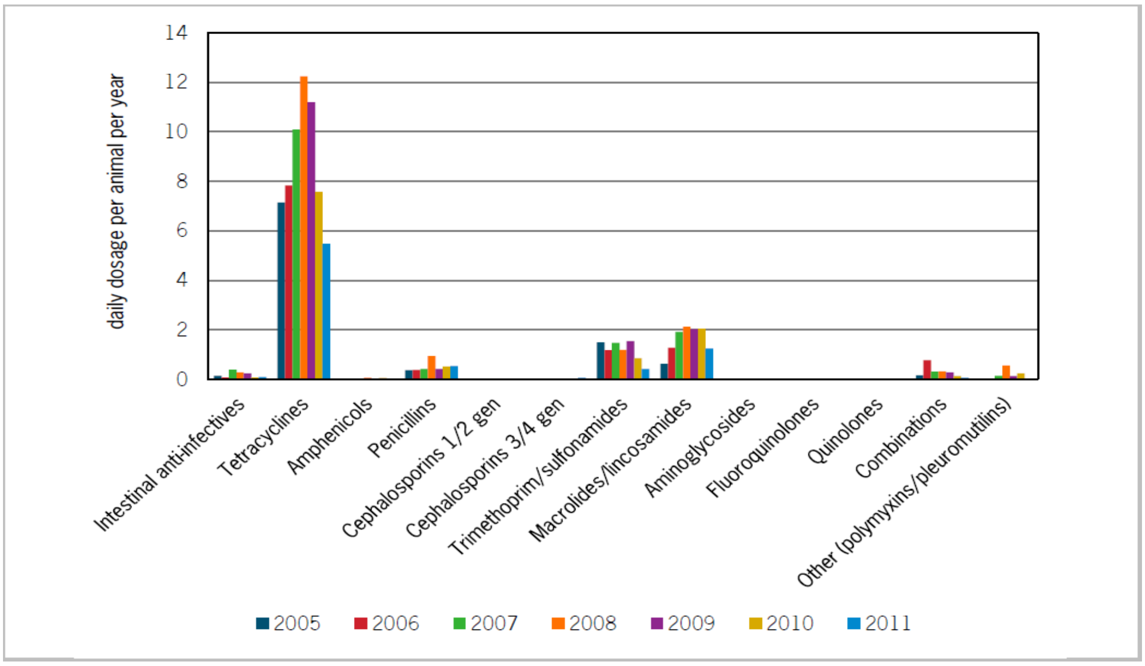


Figure 5: Antibiotic use in fattening pigs in dd per animal year in 2005-2011 (MARAN, 2012)

Tetracyclines are divided in two groups: first class tetracycline antibiotics ("typical tetracyclines") and second class tetracycline antibiotics ("atypical tetracyclines") (Michalova et al. 2004). The latter are not licensed to be used in the European Union and have no impact on disease treatments (EMEA, 1999). The substances that fall under the category of "typical tetracyclines" are: chlortetracycline and oxytetracycline; methacycline, doxycycline, minocycline, rolitetracycline and limecycline; and most recently developed is glycocycline (Goldstein et al., 1994). Nevertheless, according to Commission Regulation (EU) No 37/2010 only chlortetracycline, oxytetracycline and doxycycline are permitted to be used in livestock. In Belgium and Netherlands antibiotic residues of oxytetracycline and doxycycline have been repeatedly established in pork meat (Okerman et al., 2001). Tetracyclines can be used in food producing animals to treat the following disease (listed in order of importance and against most common diseases) (Okerman et al., 2001):

- Respiratory bacterial infections;
- Gastrointestinal infections;

- Infectious diseases of locomotive organs;
- Skin bacterial infection;
- Infectious diseases of genito-urinary tract;
- Systemic infections and sepsis;

As can be seen from Figure 5, macrolides and lincosamides also share a countable number of usages in livestock per daily dosage per animal in the Netherlands. Seven types of macrolides and two types of lincosamides are allowed as therapeutic and prophylaxis substances for food producing animals throughout the Community (CVMP, 2011). Macrolides are listed as critically important drugs in the combat with animal diseases. The Committee of Veterinary Medicinal Products highlights the importance of prudent use to restrain antimicrobial resistance due to the fact that macrolides are widely used also in human health care. Yet, macrolides that are of no importance in human medicine are tilmicosin, tulathromycin and tylosin (Dickson and Wang, 2010). Pneumonia, enteritis and arthritis are the main diseases to be treated with injectable macrolides and also they can be recommended as first choice in the course of treatment (CVMP, 2011). Yet, according to Figure 5 and based on personal correspondence with an expert on antibiotics in pig health care, tetracyclines appear to be more preferred and used drugs to treat and prevent diseases when hogs are close to be slaughtered (Geijlswijk, I. M. van, 2012).

2.2. Maximum Residue Limits (MRLs)

As a consequence of the antibiotics usage in food producing animals, antimicrobial residues might be present in the meat products (Nisha, 2008). As concluded by FAO and WHO (1998), “zero risk” is not possible to be achieved in the concern of food safety, particularly regarding antibiotic residues and their primary natural appearance in the environment, these are part of the European Union risk management to identify, assess and prioritize risks (FAO and WHO, 1998; EFSA, 2012b). In the European Union, the body responsible for the evaluation of medical drugs is the Committee for Medicinal Veterinary Products (CVMP) of the European Agency for the Evaluation of Medicinal Products. Hence, the most important thing to be taken into account towards introducing a veterinary drug in question is the explicit risk assessments on the residues of the drug. The steps involved in risk assessment (hazard identification, hazard characterisation, exposure assessment and risk characterisation) provide scientific sound and reliable risk management approach for the decision- (and policy-) maker to solve the problem instead of simply banning the hazard (Hurd, 2011). Hence, considering the risk characterisation will provide the need whether MRLs need to be estimated or not for the specific drug. Defining the safety of drug in question is done on the base of type and amount of residue “that may be ingested by human beings over a lifetime without an appreciable health risk expressed in terms of acceptable daily intake (ADI)” (Reg., No 470/2009, Article 6(1)). In other words, everything which has not been authorised is deemed to be prohibited in accordance to Regulation (EC) No. 470/2009 of the Council, May 6, 2009. In terms of residues of veterinary medicinal products we understand “all pharmacologically active substances, expressed in mg/kg or µg/kg on a fresh weight basis, whether active substances, excipients or degradation products, and their metabolites which remain in food obtained from animals" (Reg. (EC) No 470/2009, Article 2(a)). From one hand, they raise the concern about the transfer of drug-resistant bacteria to the human, and from the other, residues have an impact on the processing of the food products, e.g. inhibition of ferments (Kjeldgaard et al., 2012). Furthermore, antibiotic residues in food are related to the following pathological effects (Nisha, 2008):

- Carcinogenicity (observed in antibiotics like Sulphamethazine, Oxytetracycline, Furazolidone);
- Hepatotoxicity (drugs reported to cause liver damage);
- Bone marrow toxicity (Chloramphenicol);
- Allergies (Penicillin);
- Nephropathy (kidney damage - Gentamicin);
- Reproductive disorders;
- Autoimmunity;
- Mutagenicity;

Last, Maximum Residue Levels are residue levels that remain in tissues or "the maximum concentration of a residue of a pharmacologically active substance which may be permitted in food of animal origin" (Reg., No 470/2009, Article 1(a)). Hence, the primary purpose of establishing MRLs is to ensure the protection of the consumer against possible harmful effects resulting from exposure to residues. Where necessary, MRLs should be established for all food commodities (muscle, fat (fat and skin where appropriate), liver and kidney, meat of fin fish (muscle and skin in natural proportions), milk, eggs and honey) from food producing animals. Establishment of MRLs must be done on each and every active substance in veterinary medicinal product of concern in the EU. After that, the European Commission is in charge to set the Maximum Residue Levels after adoption by the Standing Committee, following an opinion of the Committee for Veterinary Medicinal Products. List of antibiotics and their specified MRLs can be found in the Annex, Table 1 of allowed substances published in Council Regulation (EC) No. 37/2010. However, for the purpose of this research only those who were discussed in the previous section would be presented in Table 1: Selected allowed veterinary antibiotic substances and their estimated MRLs (Reg. No 37/2010/EC).

Table 1: Selected allowed veterinary antibiotic substances and their estimated MRLs (Reg. (EC) No 37/2010)

Pharmacologically active cubstances	Marker residue	Animal species	MRL	Target tissue	Therapeutic classification
Chlortetracycline	Sum of parent drug and its 4-epimer	All food producing species	100 µg/kg 300 µg/kg 600 µg/kg 100 µg/kg 200 µg/kg	Muscle Liver Kidney Milk Eggs	Anti-infectious agent/ antibiotics
Oxytetracycline	Sum of parent drug and its 4-epimer	All food producing species	100 µg/kg 300 µg/kg 600 µg/kg 100 µg/kg 200 µg/kg	Muscle Liver Kidney Milk Eggs	Anti-infectious agent/ antibiotics
Doxycycline	Doxycycline	Porcine	100 µg/kg 300 µg/kg 300 µg/kg 600 µg/kg	Muscle Skin and fat Liver Kidney	Anti-infectious agent/ antibiotics
Tilmicosin	Tilmicosin	Porcine	50 µg/kg 50 µg/kg 1 000 µg/kg 1 000 µg/kg 50 µg/kg	Muscle Fat Liver Kidney Milk	Anti-infectious agent/ antibiotics
Tulathromycin	(2R,3S,4R,5R,8R, 10R,11R,12S,13S, 14R)-2-ethyl-3,4,10,13-tetra-hydroxy-3,5,8,10,12,14-hexamethyl-11-[[3,4,6-trideoxy-3-(dimethy-lamino)-β-D-xylo-hexopyranosyl]oxy]-1-oxa-6-azacyclopent-decan-15-one expressed astulathromycineq uivalents	Porcine	100 µg/kg 3 000 µg/kg 3 000 µg/kg	Skin and fat Liver Kidney	Anti-infectious agent/ antibiotics
Tylosin	Tylosin A	All food producing species	100 µg/kg 100 µg/kg 100 µg/kg 100 µg/kg 50 µg/kg 200 µg/kg	Muscle Fat Liver Kidney Milk Eggs	Anti-infectious agent/ antibiotics

2.3. Withdrawal period

For whatever reasons antibiotics have been used in pig farms, a mandatory minimum withdrawal period is required in order to achieve the legally accepted MRLs (Dir. (EC) No 82/2001). A withdrawal period refers to the time that passes between the last dose administered to the animal and the time when the level of residues in the tissues, milk or eggs are lower than, or equal to, the MRL (Dir. (EC) No 82/2001, Article 1(9)). Under the General Food Law, a Dutch hog farmer is a "food business operator" therefore it is his/her responsibility to guarantee and be transparent that "food shall not be placed on the market if it is unsafe" (Reg. No 178/2002, Article 14(1)). In this case, when hogs are ready to be slaughtered, they must not contain higher than the allowed antibiotic residues in their tissues. Basically, when the law refers to the responsibilities of the Dutch hog farmers in terms of antibiotics this means he must comply with the necessary withdrawal period in order to assure that food shall be safe. The government makes it explicit that "...in the case of food-producing animals the veterinarian responsible specifies an appropriate withdrawal period. Unless the medicinal product used indicates a withdrawal period for the species concerned, the specified withdrawal period shall not be less than…" (Directive (EC) No 2001/82, Article 10(2)). The required minimum withdrawal period for food producing animals such as pigs is 28 days, as stated further in Directive (EC) No 2001/82, Article 10.

2.4. Representative study on two selected diseases

Using antibiotics in livestock is closely related to the emergence of antimicrobial resistance and The Netherlands clearly recognise this threat to the public health. Therefore, antibiotics must be used as a final resort and other factors are more important to prevent diseases like: 1) high standards of hygiene in the farm and equipment; 2) reduction of the concentration of pathogens in the air by adequate ventilation and dust filters; 3) avoid mixing pigs if possible and empty each house in units – the "all in, all out" approach (OIE, 2008). By setting priorities and goals to reduce the usage of antibiotics in livestock, The Netherlands have succeeded up to 50% reduction for the last four year. However, the most used antibiotics are from the group of Tetracyclines and they are repeatedly reported in higher levels of residues in pork meat according to the NRCPs (EFSA, 2012b). The second ones are the antibiotics which belong to the group of macrolides (see Figure 5). Determining which the most used antibiotics in Dutch hog are and which diseases are treated accordingly to the determined antibiotics led to selection of two most common diseases that emerge in finishing pigs (Table 2).

Table 2: Selected diseases which occur most often in hogs

Disease	Susceptible period	Way of treatment	Withdrawal periods
Enzootic Pneumonia	Enzootic Pneumonia is considered to be one of the most common diseases in finishing pigs causing major economic losses in pig industry. The reason for this is due to the lowered digestive efficiency of the animals which causes insufficient weight growth (White, 2013).	• Tetracyclines are one of the most effective antibiotics for treatment (Kobisch and Friis, 1996).	• Antibiotics from the group of Tetracyclines have a mandatory waiting period of at least 28 days (Purdue University, 2001; Norbrook, 2014).
Mycoplasma *hyosynoviae* Arthritis	Evidence of disease occurs in animals between 30 to 40 kg and 100 kg;	• Tetracyclines do not seem to be clinically effective (Burch, 2007). • Tiamulin and lyncomycin are used and can successfully treat the disease (Burch, 2007). • The efficacy of the treatment depends on the time when the disease is diagnosed.	• The stated withdrawal periods days on the official labels of Tiamulin packages for treatment of Mycoplasma Hyosynoviae varied between 7, 14 and 21 days, therefore the average of these values were taken and was considered that the withdrawal period for Tiamulin is 14 days (BAM, 2014; Irish Medicine Board, 2013; Interchemie, 2014).

2.4.1. Enzootic Pneumonia

It is a respiratory infection which is caused by *Mycoplasma hyopneumoniae* bacteria. The transmission of the infection can be vertical (nose to nose), horizontal (between pen mates or pigs in the same compartment) and also air-borne transmission via bio-aerosols (Nathues et al., 2013). However, often the major route of the disease spreading is not clear (Maes et al., 1996). The disease is considered as a multi-functional disease since the initial bacteria responsible for the primary respiratory infection can predispose the infected animals to concurrent infections with other respiratory pathogens – bacteria, parasites and viruses (Maes at al., 2008). This interaction between the pathogens can lead to chronicle or even secondary and more severe pneumonia infections. Due to this and in addition to the slow growth of the microorganism, the infection is extremely difficult to be isolated and therefore, to be detected on time (Maes et al., 2008). Enzootic Pneumonia is considered as economically most important disease in finishing pigs. It is also considered that delaying of the disease onset is financially justified since infection in younger pigs (14 weeks or younger) have bigger impact than older pigs (close to slaughter period) (Maes et al., 1996). However, study on the management and housing properties of the farm concluded that these cannot guarantee delay of *Mycoplasma hyopneumoniae* infection until grow-finishing unit (Vicca et al., 2002).

The disease is characterized with chronic cough, low mortality but high-morbidity and growth retardation. The symptoms may appear at age of 12 to 20 weeks, reported for production systems on the All-in/all-out principle (Maes et al., 1996). Nevertheless, there are evidence that in multi-site pig production the delay of the disease can be handled till 18-20 week of age, yet the lung lesions incidents are highest in pigs 3-5 months old (MERCK, 2013). Furthermore, due to the infection of the lungs, there are lung lesions which determine the damage of the lung tissue. It was found out that pneumonia affect growth rate proportionally to its severity and percentage of damage on the lung tissue (lung score) (Morris et al., 1995; Maes et al., 1996; Escobar et al., 2002). Therefore, the infection can be mild and severe, depending on the state of development it was detected, whether the animal suffers from it for a second time, whether there are complications in treatment and so on.

The incubation period is normally 10 -16 days (Morris et al., 1995; Maes et al., 1996). Higher lungs scores were reported for pigs showing first symptoms of coughing 1 to 30 days before slaughter and pigs with a longer period between onset of cough and slaughter had lower lung scores (Morris et al., 1995; MERCK, 2013). In a study where nursery pigs were intentionally infected with *Mycoplasma hyopneumoniae* pathogen showed that in 14 days after inoculation the lungs were affected by 4.5% and after the 28th day – 14.1% (Escobar et al., 2002). However, it should be noted that in real-life situation the risk of interaction of the primal pathogen with secondary pathogens is higher, which additionally contributes to the severity of the disease.

The economic relevance and the losses due to the respiratory infection are calculated mainly on the basis of the production performance of the hogs. Apart from the reported damages on the lungs, Enzootic Pneumonia affects the average daily growth rate and the feed conversion ratio. Those two economic factors are highly important for the production costs and thus for the final profit.

Average daily gain is a significant factor in estimating growth rates in food animal species. Generally, the hog producer aims faster growth so that the animals to achieve market weight for shorter periods of time using the least amount of input in order to obtain higher profit at delivery. In Netherlands the average daily growth rate of hogs is 0.772 (Fowler, 2007). However, when hogs are infected with *Mycoplasma hyopneumoniae* the average daily gain is reduced by 12.7 ≈ 13% (Maes et al., 1996). Furthermore, several studies suggest that the daily gain is closely related to the stage of the infection and the percentage of lung damage (lesions) and the average daily gain is decreased by 0.230 kg to 0.370 kg for every 10% of pig lung affected by pneumonia (ECO, 2013; Morris et al., 1995). In addition, a slaughterhouse survey of pig lungs performed in Northern Ireland showed that lungs can be affected by typical Enzootic Pneumonia with 87% lung score (ECO, 2013). Morris et al. (1995) reported for average 4 to 5 days delay to slaughter for pigs with lung lesions or with history of coughing. Furthermore, signs of coughing in the 14 week of age were related with average 6.2 to 6.9 kg lighter than pigs which showed no signs of coughing (Morris et al., 1995). Therefore, for the upcoming economic analysis, was considered severe pneumonia infection with 70% lung lesions with average of 0.030 kg for every 10% of affected lung, resulting in 0.562 kg/day weight gain (see Table 3).

Feed efficiency conversion is a measurement unit used to indicate the efficiency of the animal to convert feed mass. The lower the feed conversion coefficient is, the better and easier the animal gains daily weight. Hence, the combination of low feed efficiency conversion and high daily gain is the best possible way to achieve high profitability. The average feed conversion ratio in Netherlands is reported to be 2.78 which is considered one of the lowest compared to others Member States (Fowler, 2009). However, epidemiological studies have observed that it can be reduced up to 13.8% when animals are infected with Enzootic Pneumonia (Maes et al., 1996).

Mortality rate is a measurement of death among a population. The average swine mortality rate in Dutch finishing farms is 2.5% (Fowler, 2009). In a research investigating the potential benefits of vaccinations against *Mycoplasma hyopneumoniae* was observed that the mortality rate in the control pigs (those who are not vaccinated) was 9.23%, while in the vaccinated group of pigs was 9.11% (Maes et al., 1998). In severe infections where *A. pleuropneumaniae* pathogen acts as secondary agent, the mortality rate can be 20% (Maes et al., 1996). In this current paper, mortality rate of 9.23% is assumed when disease is treated with antibiotics, where mortality rate of 20% is assumed to be involved when pigs are left untreated. Furthermore, the prevalence of pneumonia in a herd with 400 pigs was reported to be 54% (Maes et al., 1998).

Effect on labour hours is generally, when a disease occurs in the herd this would require additional labour hours for surveillance, testing and treatment of the disease. There is lack of literature on this topic, therefore for the cost/benefit consideration; it is assumed that these circumstances would require an average of 1h extra labour time per ton slaughter weight.

Given this information, it can be concluded that Enzootic pneumonia can have a mild and severe stage of infection and can be very persistent disease with rather high prevalence in a herd. Furthermore, the reduction of the average daily gain and the increased feed conversion jeopardize the normal production performance of the herd and the ultimate economic outcome. For the upcoming economic analysis a severe pneumonia infection will be considered.

2.4.2. Mycoplasma *hyosynoviae*

It is a swine-specific mycoplasma that survives in the environment and causes infectious arthritis. The incubation time is of 4 and 9 days (Nielsen et al., 2001). The clinical signs of arthritis, such as lameness and no willingness for the animal to stay on its feet due to pain (dog-sitting position) may or may not occur; however, in the latter case when animals have been tested they showed positive results for arthritis (Nielsen et al., 2001). However, lameness due to arthritis may be also caused by several bacterial infections, such as *Streptococcus suis, Haemophilus parasuis* and *Erysipelothrix rhusiopathiae* (Nielsen et al., 2001). Clinical signs have been observed more frequently in finishing pigs (between 40 – 100 kg) (Jensen, 2008). In addition, the primary pathogen causing arthritis, *Mycoplasma hyosynoviae,* can favor conditions of *M. hyopneumoniae* infection which greatly can influence the growing performance of the animals, if such case occurs. Although the mortality is not high, the prevalence of the disease varies from 10 to 30% in a herd and causes high morbidity – up to 50% in a herd, where often very sick animals must be prematurely culled (Jensen, 2008). However, due to insufficient literature on the correlation between mortality rate and arthritis infection, for the economic analysis a mortality rate of 7% was assumed. It has been reported that the growth rate can be reduced with 50% from the average growth rate of a healthy animal (Jensen, 2008). Another research on the disease stated that the growth rate in the infected animals varied from 0.690 to 0.850 kg/day (Nielsen et al., 2001). Since, the average daily gain is estimated to be 0.772 kg/day, then the average of 0.690 and 0.772 kg was taken into account for the economic analysis, which equaled to 0.731 kg/day weight gain in case of arthritis infection. It has been further reported that joint-disease implied 30-90 min extra labour due to regular surveillance and treatment every day per 1000 pigs (Nielsen et al., 2001). There is insufficient amount of information on how the feed conversion ratio is affected in the presence of arthritis infection. However, few studies reveal that there is no significant difference in the correlation between feed conversion ratio and lameness due to arthritis (Jensen et al., 2007). Therefore, for the upcoming economic analysis coefficient of 2.78 was used in case of arthritis infection. Hence, given the gathered information, arthritis was considered as a mild infection compared to the pneumonia, which is seen as a severe infection (see Table 3).

Table 3: Main production performance values

	Av. daily growth rate (kg/day)	Feed conversion ratio (kg feed/kg pig)	Mortality rate (%)
Healthy hog	0.772	2.78	2.5
Enzootic Pneumonia (severe)	0.562	3.08	9.23
Arthritis (mild)	0.731	2.78	7

2.5. Conclusion

Antibiotics are needed in hog mass production to maintain the health and welfare of the animals. Antibiotics are especially crucial when animals live in big herds. When antibiotics have been used, a mandatory withdrawal period is required in order to avoid unaccepted level of residues in the end food product. Antibiotic residues in food pose large variety of risks; however, the biggest concern is the risk of unsafe fermented meat products and the development of antibiotic resistant bacteria which can endanger the human health. There are several ways to tackle this problem; so far, the most considerate ones are the exclusion of growth promoting antibiotics from the European livestock production which aimed to reduce the usage of antibiotics and secondly – setting MRLs for the antibiotics. Furthermore, Netherlands achieved 50% reduction of the livestock antibiotic usage; however, the two most used groups of antibiotics remain to be Tetracyclines and Macrolides. Based on this information and elaborated literature study on swine disease, were considered two diseases (severe enzootic pneumonia and mild arthritis infection) that occur most often in finishing pigs and which diseases were used in the performed economic analysis. Furthermore, it was observed that diseases can the production performance to varying degrees once the herd is infected with the pathogen. It was also concluded from the current practises in hog production that if a group of animals is diagnosed ill, then the whole herd/batch will be treated in order to prevent spreading of the disease.

CHAPTER 3

Legal framework and external factors influencing compliance behaviour of hog farmers

In the following chapter the legal framework concerning antibiotic usage in hog farms will be addressed. The purpose of this chapter is to reveal the correlation between legal rules and responsibilities of the Dutch hog farmers, the authorities and the influence they have on the compliance behaviour of the target group. As said, T11 represents the main factors that influence the behaviour of the farmers, the combination and correlation between them, divided as external and internal factors. The mixture of external factors is seen by the set of laws, obligations, possibilities of control, penalties, liabilities, etc. Hence, the analysis of the enforcement dimensions will reveal the external factors that are relevant for the farmers and respectively may or may not encourage compliance with the law. The external factors that will be addressed in this chapter are:

- Starting point – the General Food Law with the general principles and responsibilities of food business operators in meat supply chain;
- The system (HACCP, IKB) and product (MRLs) standards that stakeholders in meat supply chains are obliged to follow under food safety law, the major stakeholders within the context of this thesis being: the farmers with their business, the veterinarians and the slaughterhouses, which together provide for the meat supply via the retailers to the consumers;
- The consequences if retailers or consumers observe abuse (like contractual and product liability);
- The checks that are made to monitor compliance of the stakeholders to the publicly set norms; relevant factors like frequency of checks will be addressed;
- The measures that can be taken by authorities in case of non-compliance (fines, penalties, etc.);

Cost/benefit considerations are addressed as external factor as well; however, these will be analysed and discussed further in Chapter 5.

In this research paper, a food supply chain approach is used in order to follow and describe the different stakeholders and the responsibilities they bear as such. This approach is considered as useful to explain the relationships between all stakeholders participating in the Dutch pork industry. A supply chain is “a network of autonomous or semi-autonomous business entities collectively responsible for procurement, manufacturing and distribution activities associated with one or more families or related products” (Swaminathan et al., 1998). There are a lot of certification systems that aim at sustainable agriculture with focus on environmental friendly production, for example "EKO" in The Netherlands. Next to them, there are the quality assurance systems that aim at healthy and safe food products, e.g. Integral chain management – 'Integrale KetenBeheersing' (IKB) systems in The Netherlands. In Table 4 can be seen that farmers and growers are rated with the highest score being responsible of performing high standards on animal health and welfare. This is only logical since they are the only one being in contact with the animals. Nonetheless, the government is involved with the same weight of responsibility. Hence, the government is the one providing the ways of control, norms and rules based on sound evidences how one must run his business without posing further complications along the supply chain; or if to say, the government takes care to see the whole picture and to think in advance. What needs to be pointed out here is that with the integrated quality assurance systems, control of the primary production phase is done with defined standards and monitoring performances revealing compliance with regulatory and customer requirements. Therefore, the government has an important role, from one hand to provide policy guidance, and from other hand to verify and audit the implementation as means of regulatory compliance (FAO, 2002). Thus, sustainable trade occurs when the relationships between all stakeholders are harmonised and lawfully restricted, leaving no place and opportunities for "mistakes" or undesired practices, such as repeated non-compliance behaviour.

Table 4: Typical responsibilities assigned to actors within the food supply chains (+ low, ++ medium, +++ high) (Smith, 2008)

UK Sustainable Development Commission priorities	actors within supply chain					outside chain	
	farmers and growers	transport and distribution[a]	processing and manufacturing	retailing	consumers and citizens	governments	research and development
safe, healthy products, nutrition and information	++	++	+++	+++	+	++	++
rural and urban economies and communities	+		+	+		+++	
viable livelihoods from sustainable land management	+		++	++		+++	+
operate within biological limits of natural resources	++				+	+++	+++
reduce energy consumption, minimize inputs, renewable energy	++	+++	+++	++	+	+++	+
worker welfare, training, safety and hygiene	+	+	+++	+++		+++	+
high standards of animal health and welfare	+++	++	++	++		+++	+
sustaining the resource	+					+++	++

[a] Includes transport and distribution both before and after primary processing and manufacturing.

3.1. Regulation (EC) 178/2002, known as the General Food Law

A decade ago, the European Union reached the point where a law tool was needed to be established in order to provide a framework that could both ensure a consistent approach but also to further guide the development of food legislation. In 2002, the European Parliament and the Council adopted Regulation (EC) No 178/2002, known as General Food Law (GFL), where definitions, general principles, requirements and obligations were laid down. Under this regulation all stages of food/feed production and distribution, known as farm-to-fork approach, were covered. In this manner, procedures in case of food safety crisis were established. The so-called Rapid Alert System, the general plan for crises management and the European Food Safety Authority are introduced for a first time, laying down its responsibility and procedures. Considering the free movement of food stuffs in the Community, this has been ensured by mutual recognition, further adopted in Regulation (EC) No 764/2008. Overall, the EU food law puts in one pace all the existing national requirements on food and feed in the Community to protect its objectives of free movement of food stuffs and food safety.

For the purpose of establishing the legal requirements for a pig farmer in terms of antibiotics use in livestock, first the applicability of the GFL needs to be assured. Therefore, meeting the definition of 'food' is essential. A pig itself is not considered as food. Nevertheless, since hog pigs are being bred with intention to be placed on the market and their meat will be further processed as food products, the meat of the pig can be considered as 'food' (Reg. 178/2002, Article 2(b)). In other words, the General Food Law makes exception for living animals which are expected to be consumed. As such, this would define a farmer as a 'food business operator' who is obliged to ensure that "the requirements of food law are met within the food business under his control" (Reg. 178/2002, Article 3(2)). The requirements of food law, not only in the General Food Law but in all other relevant legislative acts where the definition of 'food' is met, aim at a high level of protection of the human and plant health, welfare of animals and food safety.

General principles in the General Food Law

First, all enforcement tools in the sense of regulations, directives, decisions, etc. must be a subject beforehand, where applicable, to scientific risk analysis, risk assessments and risk management (Reg. 178/2002, Article 6). MRLs are strongly supported by toxicological risk assessments which mean that this criterion has been met by the government and by the competent authorities.

Second, in case of identified harmful effects on health where scientific uncertainty persists, the General Food Law introduces the objective of precautionary principle, which in the case of MRLs is advocated with the "zero-tolerance" approach (Reg. (EC) 178/2002, Article 7).

Third, the state of the food as a product must meet the food safety requirements. Food is considered unsafe when it is either injurious to human health or unfit for human consumption (Reg. 178/2002/EC, Article 14(1)). The prohibition of placing unsafe food on the market is one of the most important principles in the whole food governance. Hence, food producing animals and animal derived products that have exceeded maximum residue levels are deemed to be unfit for human consumption; therefore, these shall not be processed and/or placed on the market (Reg. 178/2002/EC, Article 14(2)(b); Dir. 96/23/EC, Article 18(1)).

Forth, the principle of transparency is considered to support and enhance the trust of the consumer in what he buys and consumes as a final product. Therefore, public representative bodies shall provide open public consultation on preparation, evaluation and revision of food law. Further, in case of a risk for human or animal health and depending on the seriousness and extend of that risk, public authorities shall inform the general public of the nature of the risk, providing all relevant information about it (Reg. No 178/2002/EC, Article 10).

Responsibilities towards hog farmers according to General Food Law

The focus of this research is the usage of antibiotics in livestock and the residues that might be present in the final product. Thereon, responsible and strict compliance with the withdrawal periods is required in order the slaughtered animals intended for human consumption to meet the legal MRLs. Nevertheless, in case of any doubt or reason to believe that the latter requirement has not been met, the food business operator needs to initiate procedures to withdraw the food in question immediately (Reg. 178/2002/EC, Article 19(1)). Further, the competent authorities must be informed by the food business operator in order to inform the general public if needed, as described above under the principle of transparency. Last, “food business operators shall collaborate with the competent authorities on action taken to avoid or reduce risks posed by a food which they supply or have supplied” (Reg. 178/2002, Article 19(4)).

Transparency is close related to traceability; in order food business operators and authorities to give relevant information on the risk of certain food commodity, this information must be accordingly traced back so that appropriate measures to be taken. In this manner, good traceability systems are acquired throughout the whole meat supply chain. The GFL is complemented by directed legislation on the platform of food safety issues such as use of food colourings and supplements, antibiotics, hormones and pesticides in the food production. The General Food Law lays down the principle of traceability where, since 1 January 2005, it is compulsory for all food and feed businesses to guarantee that all food stuffs, animal feed and feed ingredients can be and are traceable, one step back and one step forward, through the whole food supply chain (European Commission, 2012). Regulation (EC) No 853/2004 states that “the traceability of food is an essential element in ensuring food safety. In addition, to complying with the general rules of Regulation (EC) No 178/2002, food business operators responsible for establishments that are subject to approval in accordance with this Regulation should ensure that all products of animal origin that they place on the market bear either a health mark or an identification mark” (Regulation (EC) No 853/2004, Paragraph 15). In present times of dynamics on supply and marketing of food it is not enough for a food business operator just to know the customers and the suppliers he has contract with. The aim of the food traceability is to have information on the movement of the product in concern - “the journey from the grower to the consumer’s plate” (Wilson et al., 1997). Traceability of food is one way to prove compliance to a certain activity and details must be noted. In other sense, compliance is meant to be recorded according to legislation, protocols and quality assurance schemes, although they all perform different functions on different levels (Wilson et al., 1997). In addition, if a recall of contaminated food is needed, the law does not state a certain time limit other than “immediately” to complete the recall. Yet, with the principle of working traceability systems in place this is done by far quicker and more precise. Isolating only the faulty production batch would reduce all causeless costs for all trading partners and would prevent disruption of the supply chain which results in sustainable, trustworthy and safe market (ECR, 2004). Reliable traceability systems are essential to limit damage and to minimize loss of control (ECR, 2004). Therefore, the principle of track and trace is a key food safety management tool if to fulfil obligations and responsibilities of food business operators.

3.2. Good practices with respect to antibiotic usage in animal husbandry (quality control)

In order to assure good practices of traceability systems and quality control, the IKB systems were developed in the Netherlands. In the Netherlands, around 90% of the pig farmers participate and are certified by the IKB programme (Trienekens et al., 2009). The IKB (Integral chain management – ‘Integrale KetenBeheersing’) has been recognized as partial and sufficient system to accomplish requirements of hygiene regulations in primary production. The IKB regulation has been formulated in a collaborative effort of farmers, feed suppliers, veterinarians, and the processing industry. The establishment of IKB chain system in the Netherlands can be seen in response to Council Directive (EC) No 96/23. It states that Member States shall ensure that farmers and owners/persons in charge of the establishment of initial processing of primary products of animal origin place on the market only i) animals to which no unauthorized substances or products have been administered, ii) animals in respect of which, where authorized products or substances have been administered, the withdrawal periods prescribed for these products or substances have been observed and iii) products derived from animals referred to in i) and ii) (Dir. 96/23/EC Article 9 (a), 3(a)). Thereon, IKB systems are quality systems that have a focus on product safety, traceability, animal health, animal welfare and hygiene (Trienekens et al., 2009). Hence, IKB systems provide a guarantee about the methods of production which have proved to be very important for maintaining consumer’s trust in the meat production sector.

In terms of antibiotic use in livestock, a food business operator has to comply with the legal requirements applicable for Veterinary Medicinal Products (VMPs). The latter are laid down in Council Directive 2001/82/EC, implemented in the Netherlands national law under ‘de Diergeneesmiddelenwet’, 1985; ‘de Diergeneesmiddelenregeling’, 2005; and ‘het Diergeneesmiddelenbesluit’, 2005. Council

Directive 96/23/EC lays down measures to monitor substances and residues thereof in live animals and animal products, including self-monitoring and co-responsibility on the part of operators as well as the obligation for veterinarians to register date and nature of treatment, the identification of the treated animal and the corresponding withdrawal periods (Dir. 96/23/EC, Article 9 and 10). Hence, in order to prevent misuse of antibiotics only authorised person ("the veterinarian and/or the livestock owner or other authorized person") can prescribe, whether for treatment or prophylaxis, antibiotics and records including the name of the used product, the quantity, the date of administration and the identity of the animal shall be kept in two years' time at least (CAC, 1993). In addition, veterinarians have the responsibility to help minimising the need and use of antibiotics in food producing animals by promoting sound animal husbandry methods, hygiene procedures and vaccinations; but most of all to prescribe antimicrobials under their care and when those are indeed needed and necessary (OIE, 2008). Thus, the legal person to prescribe antibiotics, treat and examine animals in the holding is the approved veterinarian who must be authorised from the competent authority.

3.3. Legal relationship between farms and slaughterhouses

The governmental norms and rules in antibiotic practices in animal husbandry by no doubt guide certain behaviour and expectations from the farms. But so does the contractual relationship between farmers and slaughterhouses, which reveals certain "dos" and "don'ts" in this manner. In this section, the legal relationship between farmers and slaughterhouses will be discussed based on the public law. Regulation (EC) 852/2004 is "the most notorious" example of the public law approach to private regulation where stakeholders have the duty to regulate themselves (Meulen, 2011).

According to the General Food Law, residues and contaminants are not defined as "food" and they are not food, being excluded from the definition of "food". Nevertheless, residues and contaminants being possibly present in the food product ultimately become subject to food law because they can make food unsafe. Proper regulation and responsible avoidance of contaminants in food have much to do with the performed level of hygiene. The so-called "Food Hygiene Package", adopted in 2004, represents a body of European Union law laying hygiene rules for foodstuffs produced or imported to the European Union. There are three basic acts forming the core of the 'hygiene package': Regulation (EC) No 852/2004 on the hygiene of foodstuffs; Regulation (EC) No 853/2004 laying down specific hygiene rules for food of animal origin in order to guarantee a high level of food safety and public health; and Regulation (EC) No 854/2004 putting in place Community framework of official controls on products of animal origin intended for human consumption. All these acts are supplemented by other European Union legislation on food hygiene where the ultimate goal is to establish pro-active food policy, harmonised and recognised throughout the Community. Hence, all food stakeholders shall have HACCP systems in place in order to maintain a high level of public health.

In the present study, pig farmers are defined as "non-compliant" when they do not comply with legislation laying down the obligation to abide by the withdrawal period established for antibiotics in order to meet the legal maximum residue limits. At European level, this obligation is laid down in Annex I, part A, 4(j) of Regulation (EC) No 852/2004, stating that farmers are obliged to "use veterinary medicinal products correctly, as required by the relevant legislation". Correct use means amongst others abiding the instructions of use regarding the prescribed withdrawal period on the accompanying package (Dir. 2001/82/EC, Article 58(1)(g)). Therefore,

3.3.1. Contractual relationship between farms and slaughterhouses

Nowadays, the focus of the agricultural practice has shifted from productivity to sustainability and variety of rural functions (Commandeur, 2006). Incentives for applying traceability systems are driven by the pressure of the law. However, the same objectives have been enforced in advance due to consumer demands on transparency and traceability to assure food safety, especially in the meat production (Sundrum, 2001). Traceability is important because it has close relationship with the objective of liability for defective products which is laid down in The General Food Law. Though, Council Regulation (EC) No 178/2002 refers to the Council Directive (EEC) No 85/374 in terms of liability issues, a later amendment have been issued in 1999 where products from primary agricultural sector are strictly included (Dir. 1999/34/EC, Paragraph 5). Before 1999, it was optional for the Member State whether to include or exclude liability for defective products from primary agricultural origin (Directive (EEC) 85/374, Article 15(1) (a)). This act is done towards meeting "the requirements of high level of consumer protection" (Dir. 1999/34/EC, Paragraph 5). With the amendment of the General Food Law, especially the principle of traceability, the European standards have become one of the strictest and regulated in this regard (Trienekens et al., 2012).

Contractual relationships between different parties are part of the private law (Meulen, 2011). Those relationships represent the vertical integration in the livestock sector and are strictly between the involved stakeholders and each party has to comply with the requirements in the contract they have agreed upon. Those arrangements are regulated by private food schemes, such as IKB quality programs and HACCP. Nevertheless, all these standards and requirements are in accordance to the law and sometimes they are even more explicit and strict than the public law requires. The incentives behind those are, with no doubt, food safety. In addition, the opportunity of the stakeholder to self-regulate himself and to receive benefits for it when his product is dealt as with higher quality in the upstream of the food supply chain is a reasonable motive to be part of such schemes. Another one is the objective of liability which such contract provides because "explicit agreements are a way to show that everything possible has been done to avoid non-compliance" (Meulen, 2011). Having a contract (a legal relationship) with another party contains its specific arrangements which must be met when trading. Providing proves of history and production practices of the meat would only benefit the information flow between stakeholders (Boston et al., 2004).

Contract liability or contract law is an “agreement that creates binding obligations between parties involved” (Meulen, 2011). The farmer agrees upon the obligation to deliver in the slaughterhouse healthy animals fit for human consumption. The slaughterhouse agrees upon the obligation to process and distribute the food products to the retailer and the latter puts on the market the food product for final purchase and consumption by the consumer. Hence, the consumer expects that all requirements along the food supply chain are met and he consumes safe food products.

Last, food business operators have interest to support traceability systems because they are closely related to the enhanced effectiveness of contract liability law as incentive for firms to place safe food on the market (Hobbs, 2003). From one side, firms are protected from free riders who incidentally or not break the law or fail to invest in good production practices; and from the other side financial and brand damages are restricted and traced down to the faulty farm in particular (Hobbs, 2003).

3.4. Control and enforcement of antibiotic residues

Council Regulation (EC) No 470/2009 has repealed Council Regulation (EEC) 2377/90 in order to fill certain shortcomings in the latter (Regulation (EC) No 470/2009, Article 29). Regulation (EC) 470/2009 allows “references to the appealed Regulation shall be construed as references to this Regulation or, as appropriate, to the regulation referred to in Article 27(1) of this Regulation” (Reg. 470/2009, Article 29). According to Article 27(1) of Regulation (EC) 470/2009, where the Commission has adopted new regulation which incorporates the pharmacologically active substances and their classifications regarding MRLs, the classification of the medicinal products remains with no modifications as laid down in Annexes I to IV to Regulation (EEC) No 2733/90.

Thereof, Commission Regulation (EU) 37/2010 *on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin* defines four different categories of medicinal products which are set in four different Annexes and introduces the legal levels of MRLs expressed in mg/kg for different kind of animal species, target tissues and antibiotics, respectively:

- Annex I represents *List of pharmacologically active substances for which maximum residue levels have been fixed;*
- Annex II – *List of substances not subject to maximum residue levels;*
- Annex III – *List of pharmacologically active substances used in veterinary medicinal products for which maximum residue levels have been fixed;*
- Annex IV – *List of pharmacologically active substances for which no maximum levels can be fixed;*

3.4.1. Inspections and frequency of checks regarding antibiotic residues in pork meat

The GFL states that "Member States shall enforce food law, and monitor and verify that the relevant requirements of food law are fulfilled by food and feed business operators at all stages of production, processing and distribution" (Regulation (EC) No 178/2002, Article 17(2)). Therefore, Member States shall establish a competent authority "to maintain a system of official controls and other activities as appropriate to the circumstances..." (Regulation (EC) No 178/2002, Article 17(2)). In the Netherlands, the established official competent authority is the Dutch Food and Consumer Product Safety Authority (NVWA) which is an independent agency in the Ministry of Economic Affairs and a delivery agency for the Ministry of Health, Welfare and Sports. As such, it monitors food commodities based on monitoring programmes and yearly established plans approved by the European Union in order to safeguard the public health, animal health and welfare. According to Council Directive (EC) No 96/23 all Member States need to adopt and implement a national residue control plan (NRCP) for defined groups of substances (Directive (EC) No 96/23, Article 5). In addition, the NRCP is implemented on the basis of Regulation (EC) 882/2004 where Article 3 deals with the general obligations with regard to the organisation of official controls; Council Directive (EC) 96/23 where Article 3 to 7 deals with the requirements for residue monitoring plans and Regulation (EC) 37/2010 lays down Maximum Residue Limits (MRLs) for residues of pharmacologically active substances in food. The purpose of NRCP is to survey samples taken on-farm level and at abattoir level with purposes to detect illegal treatment or controlling compliance with the maximum residue limits for VMPs according to the Commission Regulation (EC) No 37/2010. Hence, the NVWA is the official responsible body for collecting the data and sending the results of the surveys which shall take place each year under the supervision of the Commission.

Thereon, meat inspections are needed in order to minimize the risk of humans becoming exposed to microbiological and/or chemical hazards and to serve in achieving the mentioned above legal requirements. In fact, no inspection can remove or control all hazards but their effectiveness could be increased if inspections are focused on "the most important hazards found in the population of interest" (Danish Veterinary and Food Administration, 2008). In other words, the purposes of inspections are to evaluate whether or not the commodities are fit for human consumption. With the establishment of all relevant pro-active systems (such as HACCP) and requirements in the food sector, e.g. those laid down in Regulation 852/2004, Regulation 853/2004, Regulation 178/2002, inspections will easily identify whether a certain business is doing well or not (Regulation 854/2004, Article 4).

Meat inspections can be two types:

- *Ante-mortem* (living animal) inspection - visual inspection – "aims to identify animals with clinical signs of disease, including signs of intoxications, or of a recent medication, such as injection sites, loss of body fat or alterations at the reproductive organs" (EFSA, 2011);

- *Post-mortem* (carcass) inspection – "The visual inspection of the carcass (and offal) may allow in some cases the identification of gross alterations in the carcass composition, and organ-specific lesions in kidneys, liver or other organs that are indicative of recent drug use or acute or chronic exposure to toxic substances. This aspect is not covered in detail in the current meat inspection protocols" (EFSA, 2011).

Sampling is another way of inspecting animals. In fact, each sample can be analysed for determining the presence of more than one substance (Dir. 96/23/EC, Annex IV). At the slaughterhouse the inspection is done either by target sampling or suspected sampling. Residues of VMPs, listed in Directive 96/23/EC, are classified as Group B (1) and (2) which means that they are considered as low or negligible potential concern due to the low toxicological profile of the residues of these compounds. In addition, sampling plans are made correspondent to the current production systems and age of the animals. Fattening farms are rather homogenous in animal population and age (being slaughtered at a younger age) and generally those farms must have operational protocols based on HACCP and with Food Chain Information (FCI) data. For these reasons, in the context of exposure to contaminants and tissue residues, fattening farms are considered with a low-risk profile. In addition, establishing IKB quality schemes improved the focus of the meat inspections which are performed explicitly on the basis of exchanged FCI available at the slaughterhouse prior to slaughter (Danish Veterinary and Food Administration, 2008). This system allows creating of risk profiles (risk based meat inspections) at farm level with respect to a certain set of performance standards that have to be met (Danish Veterinary and Food Administration, 2008). Or else, the primary reason FCI data to be implemented is to provide appropriate and detailed information on the pre-history, as well as ante-mortem inspection findings. Thus, upon arrival at the slaughterhouse the marketed pigs, intended for slaughter, to be easily and accordingly categorised into higher or lower potential risk groups based on the provided information, in specific "Epidemiological intelligence (data from herd health plans, monitoring/surveillance, medicine and veterinary treatments)" (EFSA, 2011). Once again, traceability tools are seen as incentives of compliance practices. However, recent study on FCI data concluded that FCI data sheets cannot be thoroughly trusted regarding compliant behaviour with withdrawal periods and do not guarantee for absence of antibiotic residues (Wagenberg et al., 2012). There are 5808 fattening farms in Netherlands, from which according to the last available EFSA report on monitoring of veterinary residues in swine, 2685 samples have been tested for contaminants of group B1 (Antibacterial), in which group belong antibiotics like Tetracyclines and Tiamulin (EFSA, 2011). The report also states that 1.2% of the collected samples correspond to "non-compliant", hence, the levels of VMPs residues are above the legal MRLs (EFSA, 2011). The collected samples must account at least 0.05% of the total number of animals slaughtered per year because "the numerical basis for calculation of the value of 0.05% is the number of slaughtered animals reported in the previous year" (EFSA, 2011). Inspections are carried out by the competent authorities without any prior notice (Dir. 96/23/EC, Article 12).

Basically, in the Netherlands inspections are performed at three levels. First, it is the self-monitoring on the farm where certified veterinarians guarantee that the animals put on the market are in line with the legal requirements (Dir. 96/23/EC, Article 9). In addition, Preamble No 13 of Council Regulation (EC) No 882/2004 *on official controls performed to ensure verification of compliance with feed and food law, animal health and animal welfare rules* defines the frequency of official controls to be as "regular and proportionate to the risk, taking into account the results of the checks carried out by feed and food business operators under HACCP based control programmes or quality assurance programmes, where such programmes are designed to meet requirements of feed and food law, animal health and animal welfare rules. Ad hoc controls should be carried out in case of suspicion of non-compliance. Additionally ad hoc controls could be carried out at any time, even where there is no suspicion of non-compliance" (Reg. No 882/2004/EC). Second, there are internal and/or external inspections done by certified institution where the focus is on the food chain information (register of the animals and positive list of antibiotics), certified feed suppliers and hygiene in the farm and compliance to the quality control programmes, such as HACCP and IKB. And third, there are inspections performed by the official competent authorities. Where, Preamble No 4 of Regulation (EC) No 854/2004 states that "official controls on products of animal origin should cover all aspects that are important for protecting public health and, where appropriate, animal health and animal welfare. They should be based on the most recent relevant information available and it should therefore be possible to adapt them as relevant new information becomes available" (Reg. No 854/2004/EC, Paragraph 4). Although, there are relatively small number of reported human cases exposed to antibiotic residues in meat, consumers are yet highly alert on this issue (EFSA, 2011). Therefore, antibiotic residues can be related more to the public concern rather than presenting high priority food safety objective.

3.5. Consequences for a non-compliant pig farmer

In the present study, pig farmers are defined as "non-compliant" when they do not comply with Regulation (EC) No 82/2001 laying down the obligation to abide by the withdrawal period established for antibiotics in order to meet the legal maximum residue limits. The latter is taken into account in Regulation (EC) No 853/2004 along with Council Directive 93/26/EC, where according to Regulation (EC) No 854/2004 when a violation to any of the above is committed "the competent authority shall take action to ensure that the food business operator remedies the situation" (Reg. No 854/2004, Article 9(1)). Further, the action taken should be decided upon the nature of non-compliance and the food business operators' past record with regard to non-compliance.

When violation is committed, in the means of exceeding the levels of maximum residues, an investigation should be carried out by the competent authority. As applicable, the investigation should be done on the premises of the farm of the origin or departure, in order to determine the reason why the levels have been exceeded (Dir. 96/23/EC, Article 18(1)). In accordance to the reason, the competent authorities will take measures to protect public health which may include “prohibiting animals from leaving the farm concerned or products from leaving the farm or establishment concerned for a set period” (Dir. 96/23/EC, Article 18(1)). Hence, products or carcases with the presence of exceeded MRLs are declared to be unfit for human consumption. Consequences, therefore, are two-fold: one comes under the public law – fines set by the law, more intensive and frequent inspections; but also if a farmer breaks the rules of the contract he has with the slaughterhouse, he can bear the consequences coming from the contractual liability under the private law.

Consequence I: If the suspicion of violation is justified due to positive samples and in a result of the carried out investigation then the owner of the farm or the person in charge of the animals is obliged to pay the expenses of the analysis (Dir. 96/23/EC, Article 19(1)) (see Table 5).

Consequence II: Farmers who fail to comply with the IKB Pigs assurance system shall face sanctions where the most severe one is exclusion from the scheme for a minimum of one year (ISN, 2004).

Consequence III: If infringements of maximum residues levels are repeatedly reported and products have been placed on the market, no matter that, the competent authorities shall carry out “intensified checks on the animals and products from the farm and/or establishment in question” in the period of six months (Dir. 96/23/EC, Article 18(2)).

Financial Consequences: Farmers who put on the market animals with higher than the legal MRLs are fined in category 3 and must pay the amount of 7800 euro (Staatsblad van het Koninkrijk der Nederlanden, 2012, Artikel 8A.13).

Table 5: Fees in the Dutch meat industry (Dwinger, 2011)

Hygiene inspection	€ 117
Ante-mortem	€ 77, 57
Post-mortem	€ 42, 14
Fee per 15 minutes • Ante-mortem • Post-mortem	 € 26 € 19
Re-examination of samples, emergency	€ 281
Non-compliance fine	€ 7800

3.6. Conclusion and reasoning on the isolated external factors influencing compliance behaviour

One of the lessons-learned through years of food safety crises and big disruptions in the food chains is that a sustainable food market is a proven way to maintain a high level of safe and quality food products (Trienekens et al., 2006). There are a lot of certification and quality assurance systems that aim at sustainable and safe food production, e.g. the worldwide knows HACCP, GAP and IKB systems in The Netherlands. All together they present the meaning and conception of "a sustainable meat production" – safe and quality food products produced with good and fare practises on health and welfare of the animals. If safe, healthy and sustainable food is to be achieved then all market players, from the very beginning of the food supply chain to the very end of it, have to play their part rightfully and justified. There are three parties which influence the state-of-the-art of the supply chain: businesses involved in the trade market, good governance by governments and the influence of the civil society organizations with sound grounds in society. The demand on high quality meat products, traceable and transparent supply chain enhances the control and enforcement of the standards in food production. The elaboration and the importance of the authorised quality assurance schemes are an indicator that the public governance shifts to a more hierarchical form of network management, self- and public-private partnerships. In a result, the background tasks from the government are transferred to the business where creating the support of policy and the feasibility of the rules are of a great importance. Through the years, the government have been increasingly pushed to a situation that the industry is primarily responsible for food safety. The government only provides the rules (legal standards for food safety), but it is the industry that must ensure and demonstrate that they comply with those rules. The role of the quality assurance schemes is to monitor their partners for compliance and to assure that the criteria are met. Then, the public institutions only have to "supervise the supervision" to the point whether all food safety standards are taken into account. The participation in IKB quality system is a business necessity but also a social peer. From one point, a farmer cannot sell his animals to the slaughterhouse unless he present a record on the health status, the antibiotics that were administered to the animal and the relevant withdrawal period needed for the substance to be in accordance with the legal MRLs (Reg. 853/2004, Annex II, Section III, 3(b)(c)). And from the other hand, even in case of violation which might not be caught at the slaughterhouse, these records have to be kept at least three years in case of physical inspection at the farm. The social awareness and the established Dutch hog community of IKB schemes, enhances the external factors such as horizontal supervision (other than the authorities but from the public), risk of inspection (by the authority) and for example the potential loss of creditability of IKB certificate (severe of sanctions) to influence the compliance behaviour in hog farmers.

Chapter 4

Factors influencing the compliance behaviour of the individual

As was discussed in Chapter 3, norms and contractual agreements between the stakeholders are ways to express external factors, which do not depend on the farmer but on the business environment he is operating in, such as severity, selectivity and probability of penalties and cost/benefit considerations. These are perceived and evaluated by farmers differently and, therefore, they might not present the same priority for each of them. The influence of personal attitude and perception towards the risk, public norms, standards and obligations, will result in certain behaviour of compliance.

In the following chapter the attitude of the farmers will be addressed as next to the financial consequences, attitude is influenced by the level of risk averseness of the hog farmer. The Ajzen framework will be used where attitude towards social norms and ability to control is influencing the factual behavioural intentions of hog farmers.

Chapter layout:

The objective of this thesis is to gain insight in the factors that influence the compliance behaviour of hog farmers and to introduce a more detailed representation of the Table of Eleven, with the idea of adjusting it particularly to the target group. (Table 6: Table of Eleven); Therefore:

- Introduction to the Table of Eleven will be made – its properties, the aim of the Table and overall explanation on the dimensions that are considered as factors of "non-compliance" (4.1);
- A brief introduction to E&I compliance behaviour model will follow (4.2);
- In order to clearly understand why exactly those dimensions are taken into account in the Table of Eleven, an overview of Ajzen's theory of planned behaviour will be presented (4.3);
- Three main subjects involved in compliance behaviour (attitude, social norms and actual control) will be resolved according to Ajzen's theory; (4.4; 4.5; 4.6);
- Main findings on the factors influencing compliance behaviour will be find at the end of this chapter along with schematic introduction of the factors in the E&I compliance behaviour model (4.7);

4.1. Table of Eleven

In 1994, the Dutch Ministry of Justice started to monitor the compliance with government legislation. During the course of this project, the model of 'Table of Eleven' was developed where the main goal was to recognise the strong and weak points of enforcement and of compliance with the rules (Dutch Ministry of Justice, 2004). In general, the T11 represents eleven dimensions of compliance (T1-T11) divided in groups as "Spontaneous compliance dimensions", "Enforcement dimensions" and nonetheless "Sanction dimensions" (OECD, 2010).

- The spontaneous compliance dimensions are set of factors that would affect the incidence of willingness to comply in the absence of enforcement.
- Then, the control dimensions is the set of factors that imply the probability of detection of non-complying behaviour or the level of compliance is directly related to the probability of detection.
- Last, the sanction dimensions in the matter of severity and risk of sanction are those factors which impose the expected value of sanctions of non-compliance (Ontario, 2011).

Generally, the content of the dimensions include economic, psychological, sociological and institutional factors, based primarily on the theory of Fishbein and Ajzen's Reasoned Action Approach (Dutch Ministry of Justice, 2004). The dimensions are categorised basically in two main streams, one that provokes voluntary compliance if no governmental control is to be applied, and the other one to enforce compliance. Yet, the groups of the dimensions are in close correlation between each other and thus, influencing each other; e.g., it is only logical to expect that no sanctions will be applied if there were no inspections to detect violations (Dutch Ministry of Justice, 2004). In this way, the T11 represents a systematic way to overview the aspects which instigate non-compliance, and what aspects hold in the choice for non-compliance. The compliance behaviour of the target group is determined by a few core dimensions, most relevant ones according to the legislation in question, in result 80% of the compliance behaviour is determined by 20% of the dimensions (varying from violation to violation). Therefore, an accurate application of the model requires a specific target group and specific legislation which is meant to be evaluated (Dutch Ministry of Justice, 2004). Thus, it is essential to determine the top two or three 'key risk factors' for compliance relevant to the hog farmers in terms of antibiotic usage prior to slaughter.

4.1.1. Characteristics of the dimensions in the "Table of Eleven"

The T11 (see Table 6) enumerated eleven dimensions, T1 to T11, are grouped in two broad classes. The first class – spontaneous compliance dimensions (T1 to T6) – consists of those factors that are not under the direct control of the control agency but are more related to the individual and his perception and self-evaluation of the given situation. Thus, the term "factor" is used in much broader definition that hinders a complex of influences that guide the decision-making process to comply or not. In this paper, spontaneous compliance dimensions are referred as to "internal factors" having in mind that many of them can be controlled by the target group and have to do with the attitude towards compliance in general. Then, enforcement compliance dimensions (T7-T9) and sanction dimensions (T10, T11) will refer to the "external factors" since they represents attitudes towards activities of the law-enforcing agency and therefore are beyond the control of the group. Notably, as can be seen from Table 6, the enforcement dimensions are those which determine the risk of being caught. From T5 till T10 there is the objective of how the target group evaluates and perceives the risk from the given situation. Thus, T11 (severity of sanction) will be the actual consequences in terms of violations. Risk perception meets the definition of being the individual judgement of the likelihood of occurrence (e.g. of sanction) times the impact of the followed consequence (severity) (Yeung and Morris, 2006). Since not all farmers are the same nor have the same style of farming, it is expected that their personal risk perception will differ from one group to another.

First factor as pointed in the T11 is the awareness (people know the rule) and the clarity of the law (no vagueness or complexity of the legislation) (T1) (Elffers et al., 2003). Yet, it is argued that a person may comply with or violate a rule without any knowledge of its existence. However, it is also taken into account that being aware of the rules may provide a better understanding of how to "deceive" the system (Dutch Ministry of Justice, 2004). Nevertheless, in the T11 the lack of knowledge and clarity of the rules is perceived as a factor promoting non-compliance. As a rational weighted choice, costs and benefits (T2) associated with compliance and non-compliance are seen as important, often reported, factor that can either encourage or withhold non-compliance (Elffers et al., 2003). In this sense, costs of compliance and maintaining good reputation/imagine will be taken into account, along with the benefits of violation of the law being seen as more favourable to the business, given different scenarios. Thus, it is important to realize that both compliance and non-compliance eventually would yield a certain range of costs and benefits. Yet, when the rules are seen as reasonable and to large extend feasible as well, the compliance is considered to be encouraged by the determined level of acceptance (T3). This dimension seeks to reveal the farmer's acceptance of the rationale behind the regulation related to both: 1) the regulation objective (what is the aim) and 2) the regulatory requirements (what a farmer has to do to achieve it) (SRA, 2011). The latter can be influenced by the farmer's respect that he has towards the authority in general (T4) whether he is willing or not to abide the law. Next to this, there are the social norms, or as in T11 figurate as "informal control" (T5), is an important factor in any aspects – whether it is the social pressure that played a role as incentive for implying certain legal policy, or just the risk and influence social environment has against non-compliance in the face of other farmers, relatives, neighbours (social control), or in the face of non-governmental agencies implementing sanctions in case of neglected withdrawal periods (horizontal control). Again, there is an influence between the two dimensions because the risk of third party reporting (T6) is proportional with the level of non-official control, thus, the higher the spontaneous detection is, the less will be the tendency not to comply (Elffers et al., 2003). Then, besides the risk of being reported, a farmer perceives the risk of being inspected by the authority itself (T7). However, being inspected does not mean that a violation will be detected every time. This leaves the opportunity of facing a risk of being caught (T8) and given the control depth of inspections, either of records or physical ones, affects farmer's tendency to comply. As it was pointed out in Chapter 3, the national authorities can inspect farmers either on a random principle or selectively (risk-based approach), which is seen an incentive for compliance (T9). Finally, the perceived risk that a sanction will be imposed unconditionally upon a violation (T10) and the severity of the sanction in particular (T11) from which the non-complier will bear the consequences under it, whether by monetary misbalance and/or of the damage to his reputation.

In conclusion, if "spontaneous compliance dimensions" are driven by the farmer's attitude, personal motivation and social norms to voluntarily comply, then the "enforcement compliance dimensions" are driven by the current state of control and the possible consequences. Then, the T11 represents a list of internal and external factors where the link between them is the individual perception of both and eventually it would influence the compliance behaviour (Dutch Ministry of Justice, 2004).

Last, if the key external and internal factors are carefully mapped and pinpointed then, T11 suggests that it is possible to distinguish people into different groups based on these key factors. These groups are as follows (Dutch Ministry of Justice, 2004):

1) **Unconsciously compliant people -** the main factor that enhances compliance could be more socially coherent, in terms that the person is not aware of the rules and unknowingly comply with it because he copies the behaviour of others in the group;
2) **Unconsciously non-compliant people –** could be related to complete lack of knowledge on the rules which ultimately can enhance non-compliance behaviour;
3) **Spontaneously compliant people –** no enforcement is required because these people would comply on their own will with clear vision of the rules;
4) **Spontaneously non-compliant people –** no matter how high would be the risk of inspection, the risk of detection, the severity of the punishment, these group of people would always violate the rules;
5) **People deterred by enforcement or calculatingly compliant people –** this group of people would decide to comply even if doing so are committed to experience certain downwards, such as profit losses;
6) **Consciously or calculatingly non-compliant people –** those people would accept the risk of being caught but would consciously break the rules if doing so would bring them higher extrinsic reward;
7) The last group of people can either belong to either **"the good ones"** who respect and trust in the authorities or **"the bad ones"** who lack these intrinsic stimuli.

Table 6: The Dimensions of the "Table of Eleven" (Dutch Ministry of Justice, 2004)

	Dimensions	**Definition**
Spontaneous compliance dimensions		
1	Knowledge of the regulation(s)	The familiarity with and clarity of legislation among target group
2	Cost/benefit considerations	The tangible/intangible advantages and disadvantages arising from compliance or non-compliance with the regulation(s), expressed in time, money and effort
3	Extend of acceptance	The extent to which the policy and legislation is considered acceptable by the target group
4	General law-adherence	The extent to which the target group respects the authority resulting in willingness to comply
5	Non-official control	The risk, as estimated by the target group, of positive or negative sanctions on their behaviour other than by the authorities
Enforcement dimensions		
6	Risk of third party reporting	The risk, as estimated by the target group, that a violation detected by others than the authorities, will be reported to a government body
7	Risk of inspection	The risk, as estimated by the target group, of an inspection by the authorities as to whether rules are broken
8	Risk of detection	The risk, as estimated by the target group, of a violation being detected in an inspection carried out by the authorities
9	Selectivity of inspection	The perceived (increased) risk of inspection and detection of a violation resulting from the selection of businesses, persons, actions or areas to be inspected
10	Risk of sanction	The risk, as estimated by the target group, of a sanction being imposed if an inspection detect violation
11	Severity of sanction	The severity and nature of the sanction associated with the violation and additional disadvantages of being sanctioned

4.3. A simple representation of External and internal (E&I) compliance behaviour model

From the previous section it became clear that the T11 represents a summary of internal and external factors found to be important for compliance behaviour. Therefore, T11 represents the two sides of the coin. On the one side there are the pure psychological approach towards the factors, based overall on Fishbein and Ajzen's model of Reasoned Action Approach, calling them "internal factors". And on the other side, it deals with those factors that represent the environment itself, the legal state-of-the-art, the business sector state-of-the-art, the social peers, etc. - "external factors". In all sciences, whether social, business economics, microbiology, etc., it is a well-known fact, that the environment is the one factor that most influences the psychological and/or physical behaviour of all living units. In other words, any time when a person encounters any given external factor to his behaviour, depending on his own character, might lead him to behavioural change which is purely psychological manner. Hereby, in this paper the suggested model of compliance behaviour the "external factors" that have been included in the T11 come first, adopting the idea that the outside world peers and influences the "inside world" of humans. Followed by and taking a step further to the "internal factors". At the end certain compliance behaviour will be expected (Figure 6: E&I compliance behaviour model). The "internal factors" can be categorized under three headings which are found in the Ajzen's model of Theory of Planned Behaviour – "Attitude toward Behaviour", "Subjective norms" and "Perceived behaviour control". In the next section an elaboration on the Ajzen's theory will be carried out in order to seek and understand which of the most important factors belong under each heading. One should notice that individuals' behaviour also influence the environment or the external factors, including the occurrence of new laws, the improving of flaws in already existing, appealing others, etc.

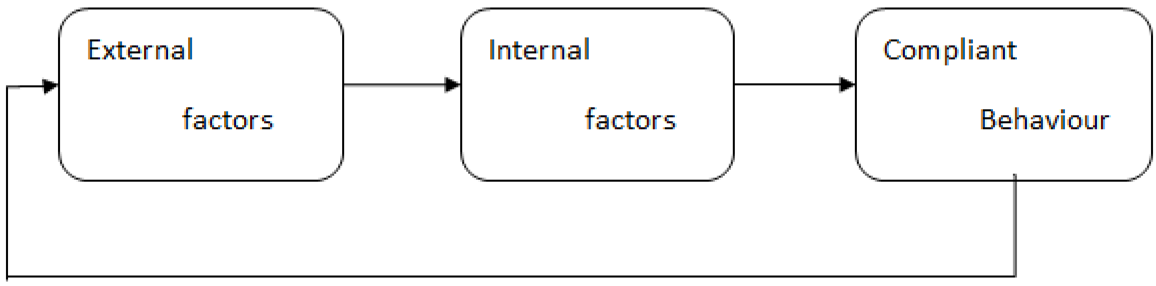


Figure 6: E&I compliance behaviour model

4.4. Theory of Planned Behaviour

There are different approaches that have been developed to explain compliance behaviour. With the use of these approaches it is possible to determine and even predict the extent of compliance. There are three theories in particular developed by Fishbein and Ajzen: Theory of Reasoned Action, Theory of Planned Behaviour and Reasoned Action Approach. There are certain differences between them and describing those differences would be beyond the scope of this research. However, Ajzen (1991) have observed that not all behaviours are under the complete control of the individual and for that he added the objective of perceived behaviour control, calling his revision 'Theory of Planned Behaviour' (Cialdini and Trost, 1998, p. 159). Applying the theory of planned behaviour would contribute to better understanding and analysing the factors from T11, particularly those concerned as "internal factors".

Ajzen developed the expectancy-value model of attitude-behaviour relationships to predict certain degree behavioural varieties (Conner and Armitage, 1998). This theory is founded on the basis that people act rationally, meaning that each person evaluates a situation with all the pros and cons and lately decides how to respond, given the considered importance which others bear towards the request, norm, and behaviour. Thus, his concept of attitude withholds the belief of rationality in humans' acts, claiming that attitudes are "a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object" (Perloff, 2010). The hallmark in the model is the behavioural intent, which compromises the missing link between attitude and actual behaviour prediction (Figure 7).

The most important principle under which the model works is when one's behaviour is under volitional control. Then, an individual's intention is assumed to be the basic immediate determinant that leads to act/behave in a certain way. It is considered that an intention is the indicator of how much one is really willing to try and plan to make efforts in order to perform the behaviour. Basically, to behave in a certain way a person needs to recognise his readiness (attitude) and his actual ability (behavioural control) to do so. Hence, Ajzen introduced the behavioural intentions as the main antecedent of behaviour, and then attitudes are introduced as one, almost separate, predictor of intentions. Further, the model also adopts the idea that no matter how ready one can be (as, for example, having a strong positive attitude towards the object/event) in some situations one can meet certain obstacles, such as lack of skills, time, money, etc. that can prevent him to fulfil the requested behaviour. The requested behaviour itself suggests that there is already another, primary existing, external factor. Therefore, intention is a function of the combination of three independent determinants: 1) Attitude towards the behaviour (positive or negative tendency towards a genuine behaviour); 2) Subjective norms (the social pressure on the subject to perform the behaviour) and 3) Perceived behavioural control (the plan to perform behaviour). The reason why these determinants are considered as independent is due to observations that in some applications it is likely to be found that only attitudes are accountable for intentions, in others that subjective norms and attitudes have a significant impact on intention, and yet in others that all three play along in human behaviour (Perloff, 2010). As in T11, such as in the Theory of Planned Behaviour, it is useful to determine the relative importance of these three "dimensions" according to the situation and the given group of people because each one can vary from one population group to another. Ajzen solved the problem by dividing it in these three determinants (Theodorakis, 1994).

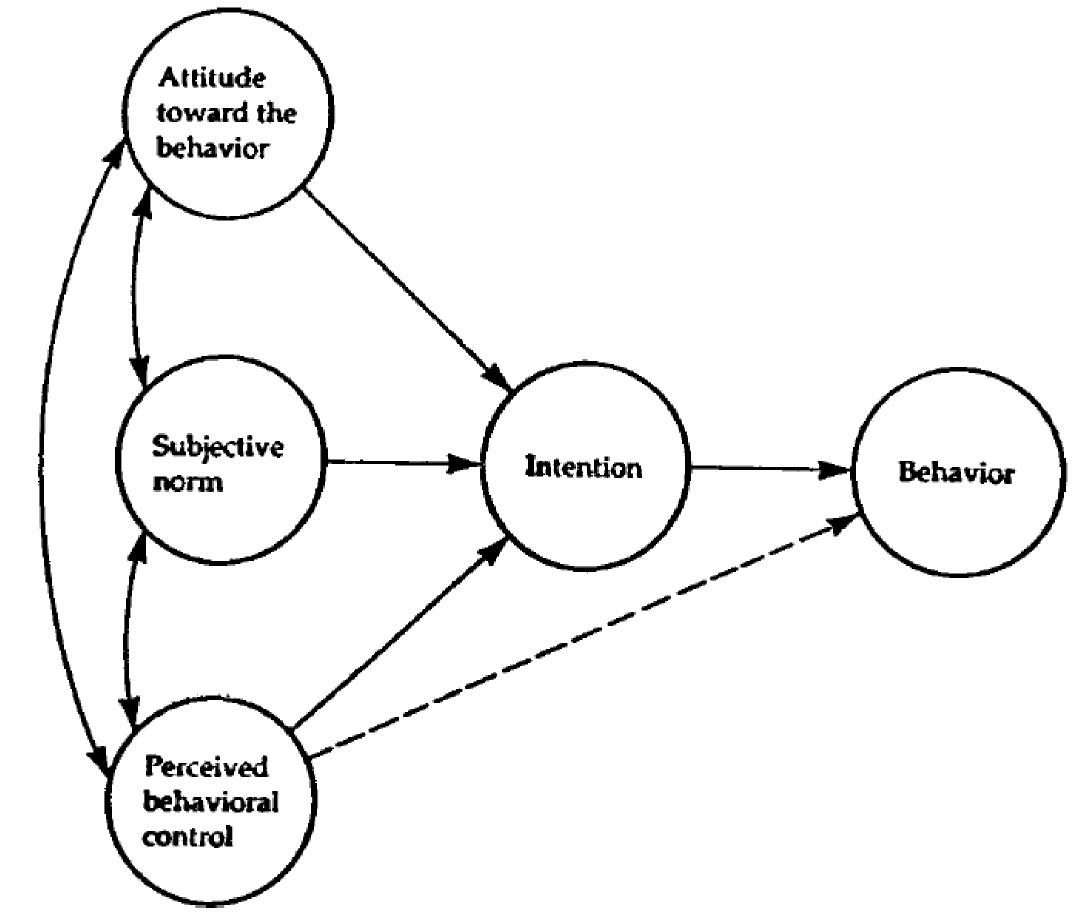


Figure 7: Schematic presentation of Theory of Planned Behaviour (Ajzen, 1991)

4.5. First determinant of behaviour intent: Attitude towards Behaviour

One of the many subjects in social psychology literature aims to explain and elaborate the ways and patterns how human behaviour is formed. It has been found that having positive, negative (or neutral) attitude can influence behaviours (Perfloff, 2010). Although, certain attitude not always guarantees the equivalent behaviour in response, therefore attitude itself is not behaviour; attitudes often can be used as a good behavioural predictor (Perloff 2010, Ajzen 1991). For this reason Ajzen included in the model of Theory of Planned Behaviour attitude towards behaviour as a first determinant. However, the question when attitudes can be used as an indicator of behaviour is important to be studied in order to understand whether farmers' attitude towards the given subject (compliance with the mandatory withdrawal periods) can be considered as a dominant factor to explain behaviour.

Ajzen considers that attitude can predict behaviour because they are formed on the basis of personal believes (Ajzen, 2005). Personal believes and personal experiences in this case are close related. According to Ajzen, beliefs are cognitions about the world – subjective certainties that an object holds a particular attribute or that an action will lead to a particular outcome, favourable or not (Ajzen, 2005). Hence, to have an attitude would mean that one have realized something and made a judgement of its net value or worth. In this manner, behaviour is a function of beliefs – if one does this; he will get that as a result, thus "behavioural belief". Then, since attitude is the individual evaluation of the situation, it is a predisposition, a state of readiness that influences behaviour in certain predictable, though not always rational, ways (Perloff, 2010). The reason why not always one's attitude leads to rational outcomes is that attitudes are not a "product" of pure affect, but for most parts they are based on emotional scales (hence, feelings can be dominant when attitude is formed) and perceptions (Schwarz et al., 2001). If feelings, personal belief, values and perceptions play important role in justifying attitude, then it can be expected that attitude is more likely to shape and dominate towards behaviour in response to social stimuli (Perloff, 2010). In this manner, a distinction between weak and strong attitudes occurs. For example, when the capacity of information is managed to be absorbed then the attitude is developed more intellectually, while others are pushed through reward and punishment of previous behaviour (Perloff, 2010). Therefore, there are certain attributes of attitudes that form the attitude-strength which in future results in stability over time, resistance to change, and a powerful impact on thought and on behaviour (Visser et al., 2006). Those attributes are: attitude importance, knowledge, certainty, ambivalence, accessibility, extremity, structural consistency, direct experience, and others (Visser et al., 2006). In the next paragraph the attributes of attitude will be elaborated in order to grasp the "whole picture" why an attitude is so important towards behaviour.

4.5.1. Attributes of attitudes

Importance – or perception of attitude, is the amount of psychological significance one ascribes to an attitude (Visser et al., 2006). How an individual decides which attitude is important becomes as result of three factors: self-interest, social identification and values (Boninger et al., 1995). A person perceives to be more involved and attitude is important when the object (person, place, or issue) is linked to his material self-interest (Boninger et al. 1995). In other words, issues tend to get more important when the outcomes are more significant and essential with respect to the lifestyle, business and privilege; or whenever wealth is involved then the self-interest comes into play (Boninger et al., 1995). Therefore, when it comes to a government policy issue, perceived self-interest is likely to be high among those who are in direct correlation with it and their behaviour is more likely to be influenced on the outcomes (Boninger et al., 1995). After self-interest and social identification there is the value relevance of the object. The large macro constructs that underlie attitudes are the values one hold and these guide people to decide which attitudes to consider important (Perloff, 2010). Values are more global and abstract than beliefs. If a person chose not to comply with the regulation he might value more his self-independency and risk not to lose money than he values the obedience of the rules and fair-play. Therefore, when the relationship between attitude object and an individual's values is perceived as close, then values become more important which brings attitude to higher importance for the person (Johnson and Eagly, 1989). The attribute of importance is seen in the model of Theory of Planned Behaviour as a background factor to the "behaviour beliefs" or importance of an issue is strongly depended on the personal perception.

Knowledge – the information that one might fully know or be not aware at all about the particular attitude object. Knowledge or being aware of rules is a very important factor in order for an individual to evaluate whether he would contribute to it or not. Attitude is only formed when one encounters the object (Perloff, 2010). Therefore, in the T11 the first dimension for compliance behaviour is knowledge of the regulation. Yet, The Dutch government and corporative agencies have already taken this into account. As was described in the previous two chapters, there are no reasons to presume that Dutch hog farmers are not aware of the norms and standards concerning antibiotics. Although, in case of violation an investigation needs to be done to determine the reason so that more relevant and effective enforcement strategy to be undertaken. Nonetheless, according to the T11 survey on hog farmers, the lack of knowledge of the regulation is considered to be as a negligible factor for non-compliance. It is reasonable to consider this as true due to the fact that every farm is working with certified veterinarians (Dir. 96/23/EC, Article 9). Further, farms that are in alliance with quality assurance programs are expected to be in even more elaborate understanding of the contractual obligations they have agreed upon. Thus, the attribute of knowledge is seen as background factor towards the "control beliefs" in the model of Theory of Planned Behaviour.

Accessibility – refers to the state of mind of how easily one can report his attitude. In other words, the time that takes one to recall in his memory of the issue, to grasp the evaluation he has for it and to report whether his attitude is positive or negative (Bruner, 1957). Accessibility rises when certain behaviour was performed continuously with the certain attitude object (Fazio et al., 1981). Thus, when related to the model of the Theory of Planned Behaviour, the attribute of accessibility is accounted as a "past behaviour" factor that influences the behaviour beliefs of an individual.

Certainty – refers to the confidence and validity one has to an attitude. One can be certain that breaking the rules is not a good alternative; other may not share the same view. In fact, it is more likely attitudes to affect one's behaviour if they are certain rather than uncertain (Bizer et al., 2006). Attitude certainty, on the other hand, is enhanced by direct experience with the object or when the attitude becomes more accessible (Fazio et al., 1978; Holland et al., 2003).

Ambivalence – refers to the positive and negative attitudes that people tend to adopt towards the same issue. For example, a person may recognize both admirable and despicable qualities in a particular individual, or may see both pros and cons of a proposed policy. A farmer might see the strong sides to comply but this relationship diminishes and he can fail to comply if the attitude is ambivalent (Conner and Sparks, 2002).

Directed experience – having already experienced certain attitude is more likely that this attitude became stronger and the chance for repeating it rises greatly. It is considered that this attribute to attitude can strongly predict future behaviour on the foundations of experienced values and beliefs (past behaviour) (Ajzen, 2005).

Structural consistency – and ambivalence are closely related since "the strength of the object-evaluation association may also be determined by the structural consistency of the attributes underlying an attitude" (Holland, 2013). If ambivalence characterises the co-existence of both positive and negative elements on the basis of an attitude then the more ambivalent an attitude is the weaker it is. Structural consistency is the implication of one's beliefs.

Extremity – the meaning of this attribute of attitude is consisted in the word itself. It is a concept where certain attitude is present on the continuum of very positive (like) to very negative (dislike). Thus, attitudes which lie on either end of this continuum are realized as extreme (Visser et al., 2006). It has been already considered that neutral attitude is not an option in this current evaluation of farmer's attitude. In fact, extremity is the only dimension which refers to the attitude itself, not to the attributes of or judgment about it (Visser et al., 2006).

In summary, nobody is born with an attitude; attitudes are learned because for the most situations they represent the evaluation of objects that an individual encounters through his lifetime. The latter is important realization, that whatever the outside world provides it is likely to enhance the same response in return. In results, attitudes are more in touch with feelings and personal believes, for which they can dominate and shape certain behaviour due to social stimuli/peers which at the end might alter irrational behaviour. The literature on strong and weak attitudes delivers the concepts on different attribute of attitudes which ultimately influence the state of the attitude. The attitude strength is not an expression of intention for behaviour nor is it an expression of confidence about one's ability to perform a given behaviour. Nevertheless, compared to weak attitudes, strong attitudes are more likely to remain stable over time, resist influence, affect thought, and guide behaviour (Visser et al., 2006). Thus, the strength of one's attitude shows not only the outcome of the evaluation (positive-negative, good-bad), but also the confidence and the predictability of one's behaviour on the basis of his beliefs and values. From the model of planned behaviour (Figure 7: Theory of Planned Behaviour) becomes clear that the three kinds of salient beliefs (personal, normative and control beliefs) are the prevailing determinants of a person's intentions and actions (Ajzen, 1991).

4.6. Second determinant in behavioural intent: Social Norms

According to Ajzen and the Theory of Planned Behaviour the second determinant towards the formation of intention to behave in certain way is the "subjective norms". The "subjective norms", also called "social norms", are driven by two components: "normative beliefs" - how one considers the significant other's attitudes towards the issue; and "motivation to behave" according the requested/expected way – the motivation that an individual gains whether to go along with these significant others (Ajzen, 1991). By capturing the moral side, the model explains that one is influenced by his own attitudes but also accounts what others think. Then, the degree to which one sees the importance of other's attitudes will affect his own motivation to abide or ignore the rules.

Social norms, in their basis, guide and/or constrain social behaviour by providing rules and standards that are understood from the members of the group without generally involving the force of the laws (Cialdini and Trost, 1998). Yet, as being a product from the interaction with others, the strength of the social norms will be depended on the: 1) access ability of the group (being informed); 2) state of acceptance and 3) the importance of the norm for the group (Cialdini and Trost, 1998). When these states of the organization are clear and “the costs associated with non-normative behaviour are made known”, member of the social network will prevent any disobedience by emphasising what other members “should” or “ought to” do (Cialdini and Trost, 1998). Although, generally, the sanctions of any deviation of the rules would be imposed by the social networks, it is also well-known that sanctions, such as laws, can be developed to support the strength and explicitness of the norms in concern (Cialdini and Trost, 1998). If a norm is to satisfy basic human needs and desires, then the power of the norm is gained by its acceptance within the culture, having in mind that the norm primarily must be communicated throughout the group in order to have any effect on the behaviour (Cialdini and Trost, 1998). In addition, it is observed that individuals are more likely to comply with the law if they perceive the same one as appropriate and relevant to their internalized norms (Herzfeld and Jongeneel, 2012). On the other hand, a low level of acceptance of the norm might result in the so called “intermittent compliance” e.g. the speed limit norm is often violated due to the fact that someone needs to be in a hurry (e.g. emergency) and he would comply every other time when he can (SRA, 2011).

In the context of this thesis the meaning of “group” is perceived as number of farmers participating, contributing and maintaining socially accepted norms and standards which are strengthened with the objective of regulations. Therefore, three groups of farmers in particular shall be distinguished – IKB farmers, non-IKB farmers and organic farmers. The latter are not of a much importance since the way of managing and breeding hogs primarily limits the usage of antibiotics, imposing that hogs can be treated only one time with antibiotics and the withdrawal periods have to be twice the length required by the veterinary authorities (Borell and Sorensen, 2004). Non-IKB farmers represent a minority and also shall be excluded in the analyses. As already stated, IKB quality systems can be recognised as a wide network within the Dutch agricultural sector, where over 90% of the pig producers participate (Trienekens et al., 2009). Yet, farmers who do not participate in IKB systems e.g. are obliged to provide urine samples from each animal on a regular basis in order to prove the absence of illegal substances (Huik and Bock, 2007). Due to the fact that this is by far very costly and labour intensive, almost all farmers have entered the IKB schemes. The main barrier for the farmers outside of the quality system is the distrust, the lack of knowledge on the benefits and how to participate and the economic viability related to the quality schemes (Huik and Bock, 2007). Since organisations can be seen as a particular type of network that integrates a formal structure and hierarchy, then the most important factors for one network to be healthy (strong) are knowledge and trust (Wielinga, 2004). Knowledge, in the sense that everyone participating in the network is aware of his responsibilities and trust, that everyone shares and applies them accordingly. Then, ultimately, some networks would generate energy where people will be willing to give their input and to attune to others, in a result of which the network gets stronger (healthy network) (Wielinga, 2004). Overall, the pork supply chain exercises less control and grants farmers more freedom than for example in the chicken and beef sectors (Boston et al., 2004). The concept agreements within the pork sector are specified on production practices and carcass characteristics, being made basically on weekly basis. At the same time, having the most production freedom, hog farmers also are at risk of financial misbalances, as prices are highly variable and there is no system of profit sharing (Boston et al., 2004). In general, when in IKB group, a farmer is expected to process information about given topic more systematically and for this he would be in a position to develop attitude towards the issue which would be more stable and more resistant to change when compared to farmers outside the network (Kahlor et al., 2006).

Thereon, it becomes evident that farmers who enter quality schemes choose this option basically because of the better prices and market distinction which eventually gains direct benefits from their participation in the scheme (Huik and Bock, 2007). In this manner, Ford (1992) states that one "organization exists when various components are combined in such a way that the whole is different than the sum of the parts" (Ford, 1992, p.22). Hence, when the involved parties receive benefits and qualities from a particular relationship and these could not be accomplished if parties were on their own then "the whole" is greater than the sum. This kind of relationship is considered as facilitating conditionality between the system components (Ford, 1992, p. 23). Conversely, constraining conditionality are these which pose reduction of the range of possibilities (Ford, 1992, p23). In this case, according to Wielinga (2004), obligations within the network can start feeling like an yoke driving people to be less willing to give their input and making the reward of cooperation lower (Wielinga, 2004). Then, the level of the opportunistic bias phenomena can arise causing distrust and economic disruption to the entire industry (Boston et al., 2004). Under the EU directive 96/23/EC the IKB schemes were approved as self-control systems (Huik and Bock, 2007). The objective that the GFL brings into the light, putting the primary responsibility for food safety in the hands of the food operators, assumes that an actor is always capable of choosing between compliant and non-compliance behaviour. Therefore, the motivation of demonstrating compliance is an important business value as stakeholders are being encouraged to report on their behaviour and to show their commitment to social norms in order to meet market expectations but also as justification for their "license to operate". From this point of view, Nicholls et al. (1990) have defined two major "brands" of motivationally relevant goal patterns: ego-involved goals and task-involved goals. The set of ego-involved goals aims to optimize the favourable evaluations of one's competence activity, reflecting and enhancing one's performance on his image (Nicholls et al., 1990). And, the task-orientated goal challenges an individual to focus on mastering the given tasks, increasing his competence (Nicholls et al, 1990).

In conclusion: when looking at compliance behaviour within the business network where norms and standards are directed by social peers and official authorities and when following the survey on Table of Eleven (Figure 8) it can be concluded that acceptance of the policy and the concern of the farm image are by far the most important factors which encourage the compliance behaviour of hog farmers. From one hand, the perception of policy acceptance comes from the tight and healthy network that IKB quality schemes provides, making sure that relevant information is systematically distributed and norms are understood. From the other hand, the subject on business competence raises the need of flawless producing performance which is in correlation with the importance of the attitude towards this issue that farmers apparently show. Farmers perceive the damage on their "name" as higher incentive to comply rather than just to pay the sanction in case of detected violation. Moreover, according to Figure 9, the perception of risk from social control (being reported by a third party (T5a)) is not evaluated as an important factor that encourages compliance. Yet, the horizontal supervision (T5b) that quality schemes and official controls provide is perceived as being important to encourage compliance behaviour. The idea of severe consequences from being sanctioned such as slaughterhouses to lose the trust in the farmer's production practices or even the farmer to be excluded from the quality programme are perceived as high risk. Thus, acceptance of the policy (T4) and the non-official control (T5) are factors which belong to the "social norms", where concerns of the image are internal factors belonging to the "attitude toward behaviour" in the Theory of Planned Behaviour.

4.7. Third determinant: Perceived Behaviour Control and Intentions

As it was stated in the beginning, the Theory of Planned Behaviour is an extension of the theory of reasoned action and the reason for this "extra" objective to be applied is that Ajzen (1991) recognised that there are certain situations where no matter what one's intention is, he might not be able to perform the desired behaviour due to lack of skills and capabilities. Perceived behaviour control is assumed to be a function of control beliefs, the beliefs about the absence or presence of internal and external factors that would facilitate or impede performance of the behaviour. If human intention captures the influence of motivational factors where the stronger the intention, the more likely the behaviour will be performed, then the performance itself is depended on certain non-motivational factors as time, money, skills, knowledge, cooperation of others, etc. (Ajzen, 1991). Therefore, this section will deal with the state-of-the-art of the farmers, in the sense of information flow, sector characteristics and product attributes. Overall, these factors represent farmer's actual control over the behaviour (Ajzen, 1991). The net profitability of farms and the considered hereafter factors will be investigated and quantified in more depth in the following chapter.

To realize what is influencing on the actual control of the target group, a study on the power distribution in the Dutch pork chain would be used. First of all, knowledge on the rules (T1 factor from Table of Eleven) must be clear and should reach all members of the target group. The moment when a famer is aware of what he needs to do and what he has been asked to do is the moment when he gains certain conscious control over his choices whether to comply or not. Thus, knowledge and level of education of the target group is expected to be part of the "Perceived behaviour control" in the model of Theory of Planned Behaviour. According to the study on the concept of power by Visser et al. (2000), the pig sector is influenced by a high level of expertise power. This would mean that the target group is influenced on practice which is based on expertise and knowledge and as being involved in an organisation, such as IKB quality schemes, the behaviour of the farmers is based solely on past experience (Visser et al., 2000; Draft, p. 364, 2008). An indication on the past behaviour is also what Ajzen perceived to hold true about predicting future behaviour in the Theory of Planned Behaviour (Ajzen, 1991). The fact that the livestock production in Europe, and generally in the Netherlands, is emphasized on safety (e.g. no growth promoters or hormones) can be explained by the pyramid created by Maslow (1943) (Figure 8: Maslow pyramid). The farmers, also citizens, of North-West Europe are well developed and profitable and many of them are even at the level of self-realization and acknowledgement (Hoste, 2010). The European livestock production is famous with the high standard of quality of products and production methods and also is better among others in solving problems in advance regarding environmental issues and production process (Liinamo and Nieuwenhoven, 2003). Therefore, the agricultural challenge of meat products with no residues is considered to be a logical factor in the development of the Dutch pig production. From the Malsow's pyramid becomes clear that meat with no residues might be challenging job if the farmer is not well off financially. In the next chapter will deal with the economic aspects that hog farms face in order to conclude whether the financial obstacle of withdrawal periods is a major factor of non-compliance.

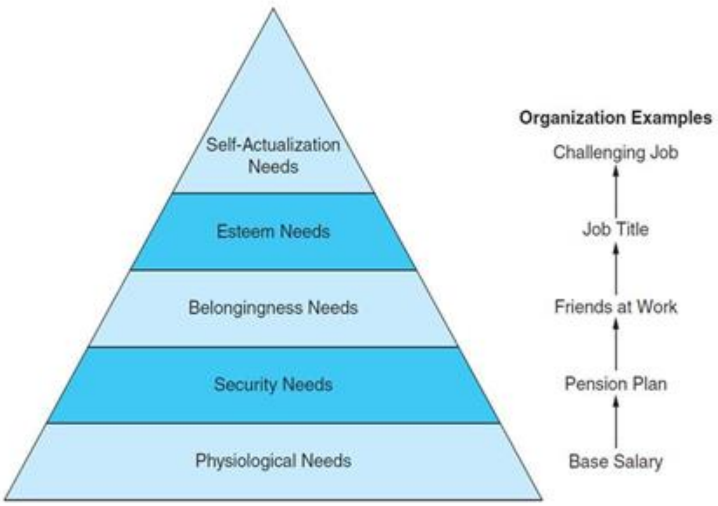


Figure 8: Maslow's Hierarchy of Needs (Maslow, 1943)

In general, the high prices of feed and to some extend the price of energy post basic problems for sufficient profitability of the pig producers (Marquer, 2010). The Dutch prices for finishing pigs are highly volatile, the price trades between the slaughterhouses and the primary producers are often negotiated and a current issue is that the payment for pigs does not reflect the true value and is not transparent (Boston et al., 2004). This results in speculations from the farmer's side, for example, if a farmer feels that the prices are going down he would sell his pigs early in order to avoid the lower price. This poses the factor of "heat of the moment" when a farmer might have the intention to comply with the withdrawal periods but the uncertainty of the market to push him in the other direction. Then, a violation would occur as not being met the product attributes of safe and quality food products. In addition, the current system of bonuses does not always encourage production of the proper attributes, meaning that if pigs are too lean they do not bring to the slaughterhouses more money, so slaughterhouses tend to reject those pigs (Boston et al., 2004). This has driven the objective of optimum weight at slaughter that encourages the current payment system. At the same time, if the animals are overweighed then the selling meat price can involve certain quality discount since the meat is considered as fat. It appears that while the responsibility of safe food products is on the farmers, “the market is no longer dominated by farmers’ cooperatives but by supermarket chains instead that show no loyalty to farmers” (Wielinga, 2004). Ultimately, it can be argued that the pig sector has stopped seeing the government as a partner that stimulates and encourages growth and farmers have begun to perceive it as the bureaucrat that is limiting the possibilities within the sector by a domain of partly unrealistic rules; hence, certain arising of constraining conditionality can occur resulting in not willingness to abide the rules (Wielinga, 2004; Ford, 1992).

4.8. Main findings on internal and external factors influencing compliance behaviour of hog farmers

Internal and external factors as they are ultimately would determine one’s intention, as being shown in Ajzen’s Theory of Planned Behaviour, would lead to particular behaviour. In this section, more elaborated explanation on the proposed model that was developed regarding compliance behaviour of Dutch hog farmers with antibiotic withdrawal period is going to be performed. As was stated in section 4.3 the premises of this new model lie on the Table of Eleven and The Theory of Planned Behaviour. With the use of Theory of Planned Behaviour and based on literature research it was managed to follow the pattern in which individuals tend to form their way of behaving. This model can be used when the target group is perceived as having volitional control, meaning that given the certain level of intentions, behaviour would more likely occur in situations where the behaviour is under the control of the actor. Then, predicting behaviour would mean to centre the attention on attitudes, beliefs, social norms, intentions, volitional control, and ultimately the behaviour itself. Based on the conducted literature research and supported by the surveillance on the T11 (see Figure 9), an isolation of the main factors for compliance was carried out. The T11 gives a handle to assess how farmers evaluate against the regulations outlook. In the questionnaire participants (pig farmers vs. experts) were asked, on the basis of the T11 of the regulations for food safety assessment. Figure 9 shows what experts have expected of the certain dimensions to serve as encouraging compliance or violation, but also gives a review on what pig farmers really perceived as such.

As can be seen from Figure 9 factors as:

- Implication of the image (cost/benefit considerations) is important for the farmer since this would lead to losing the trust and the good reputation between the farm and the slaughterhouse, reducing the farm competitiveness in the sector and even exclusion of the quality program, resulting in losing his “license to produce”;

- Acceptance of policy object (extend of acceptance) is important, since if a farmer does not believe and accept the reasons why such a policy exists his attitude towards the regulation would be weak and in contradiction to the behaviour he is asked to engage;
- Government authority (general law-adherence) is also important and it is in correlation with the acceptance, revealing the trust and respect the producers hold against the authorities;
- Social control (non-official control) – "what people would think" is important factor, revealing again the concern that farmer holds against the image of his farm;
- Horizontal supervision (non-official control) – if a farmer is certified under a quality program then he would be inspected at least once an year by the certifying agency;
- Risk of physical inspection or vertical supervision (risk of inspection) – risk-based inspections performed by NVWA;
- Risk of third party reporting – social pressure is perceived as an important factor and encourages compliance;
- Risk of sanction being imposed (risk of sanction) – pros and cons to comply or not to comply;
- Severity of sanction – reasons can be considered the same as the risk of image damage of the farm;

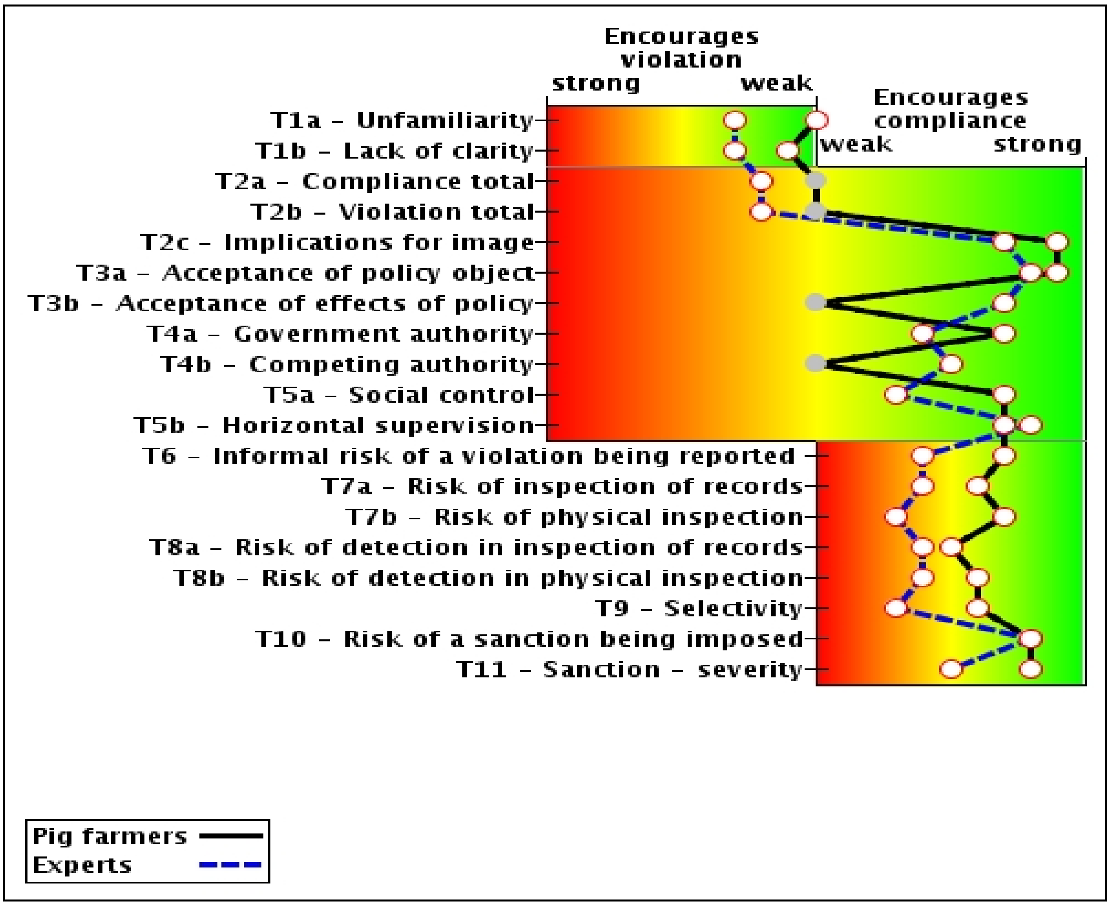


Figure 9: Compliance profile of pig farmers regarding the regulation laying down the obligation to abide the mandatory withdrawal period of antibiotics, drawn up by mean of an expert study using the digital tool of the centre of crime prevention and safety (Centrum Criminaliteitspreventie Veiligheid, 2012)

4.8.1. E&I compliance behaviour model

The current model regarding compliance behaviour of hog farmer towards withdrawal periods has been developed and presented in Figure 10. In this chapter two models have been used to represent the reality about compliance behaviour and ultimately how individuals form attitudes based on their perceptions and general evaluations of the given situation. The current model uses the perceived idea that the surrounding environment or the given external factors would persuade the individual's attitude which is generally based on his own values, norms and beliefs. In addition, it has been justified that internal factors would not play so important role if they were not under the main influence of the external factors. For example, if risk-based approach of inspections is considered, then it would be logical to assume that even though a farmer cannot have complete influence over this, he could perceive the risk of inspections lower, being aware that he is compliant or possibly higher if he is non-compliant. Overall, the conclusion from the performed literature study is formed in the direction that knowledge of the rules is by far important factor in order one to comply with the required rules. This does not reject the idea that people can comply spontaneously; however, it rejects the idea that hog farmers are oblivion of the rules, especially those participating in quality assurance schemes. In addition, it became clear that one could not simply form an attitude toward object or issue unless he encounters and experiences it. Thus, knowledge and past behaviour are seen as a matter of forming the attitude toward compliance behaviour but also a matter of perceived behaviour control. Although, having in mind that some people could be compliant without knowing of it, the more important factor when one is aware of the rules is the acceptance of the policy objective. Again, acceptance of the given situation could be influenced by external factor, for example, the way authorities enforce legislations and the way they justify the trust and respect farmers perceive about their work. This could possibly explain why the risk to be inspected by the certifying agency is perceived as higher determinant to influence compliance.

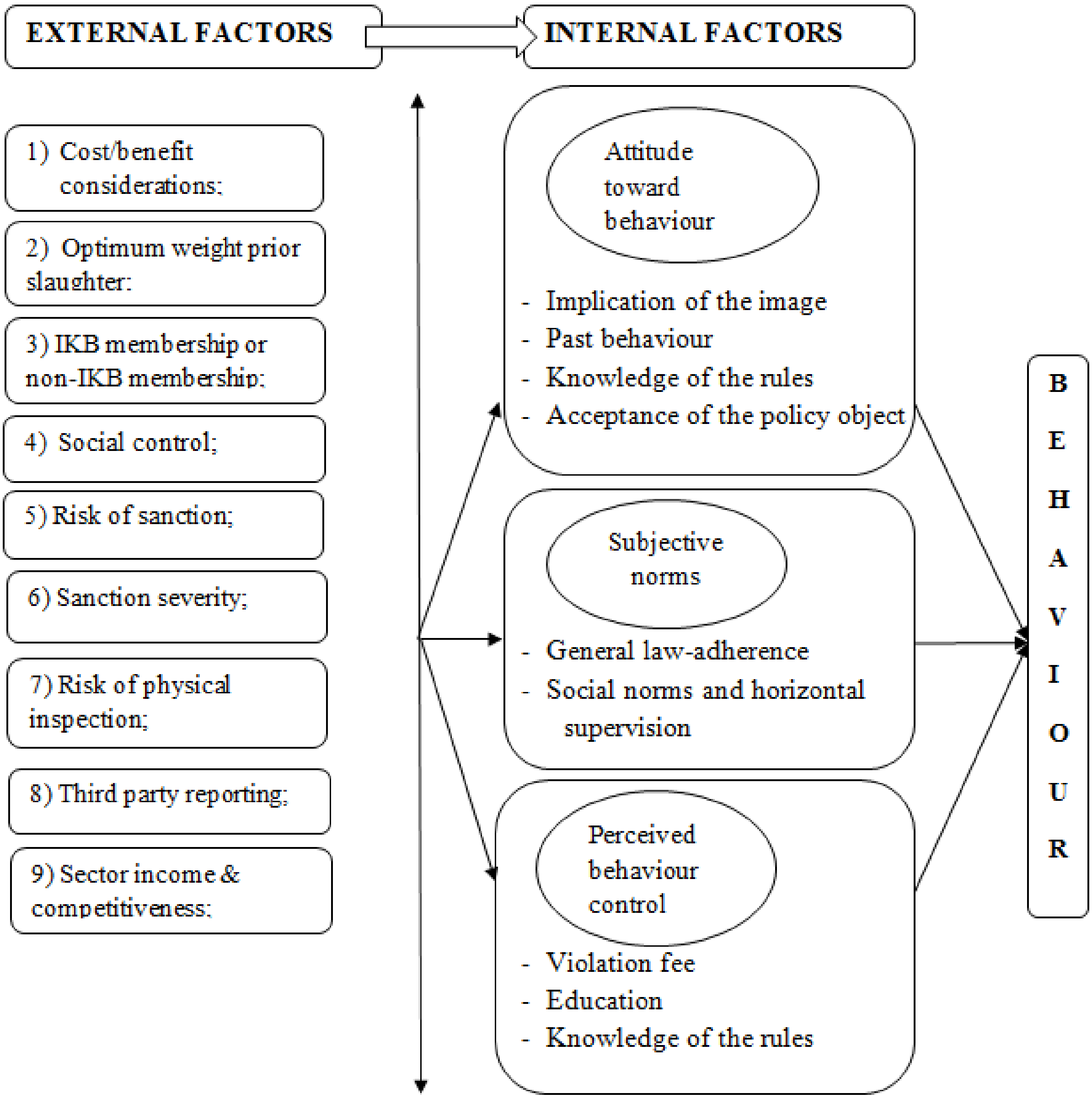


Figure 10: E&I compliance behaviour mode

Chapter 5

Analysis of the economic factors and their impact on (non-)compliance behaviour in farm disease management

5.1. Introduction

In Chapter 4 the influence of internal factors on compliance behaviour were described. As a main conclusion the argument that certain behaviour cannot be performed unless the person in question encounters a particular situation (which is seen as the influence of the external factors over the formation of behaviour) was used. For example, a car driver might be aware of the allowed speed limit, but if there is an emergency then the chance to violate the speed limit regulation is more likely than compared to a casual situation (SRA, 2011). For this reason, in the current chapter scenarios that were expected to force either compliance or non-compliance with the relevant regulations, all described in Chapter 3, are developed.

An economic model assumes that people perform a decision based on achieving the best possible economic outcome for them. Thus, it could be perceived that the farmer's main goal is profit maximization. For this reason, it is accepted that a farmer is entitled to be rational in his decisions which implies that when confronted with alternatives he would select that course of action which would yield largest profit. Hence, the aim of this chapter is to trace and isolate those factors relevant to the given situation (appliance of antibiotic and their withdrawal periods) and to conclude whether non-compliance behaviour occurs mainly on the basis of better opportunity to receive extrinsic rewards. Hence, this chapter and the following are aiming at quantifying the considered external factors.

Thus, the first step projects introduction of disease scenarios with required antibiotic treatment and timeline of withdrawal periods. Then, the second step involves description of the inventory list of the selected external factors that are considered as relevant to influence certain decision. Furthermore, this step involves calculation and gathering relevant information on the variable inputs that must be used for estimation of the average net profit that each scenario could yield. The last step is to use the calculated economic payoffs of the scenarios as an input for decision tree model, taking into account the probabilities of inspection and detection, performed via Decision Tree Analysis.

5.2. Scenarios

In this section, different scenarios will be developed and elaborated upon for further analysis. Therefore, first a layout of the different scenarios will be made. For scenarios assuming occurred disease, it should be noted that an antibiotic treatment of 7 days is assumed for all disease scenarios, since it has been reported that intensive treatment with antibiotics in Dutch livestock production should not exceed 7 days (Danish Agriculture and Food Council, 2014). In addition, disease scenarios share similar course of events, meaning that there are two main stages of development. The first one is healthy stage (average daily growth of 0,772 kg/day) – the duration of which can differ from one scenario to another. However, the second stage – sick and recovery stage (average daily growth is according to the particular disease in question, hence less than 0,772 kg/day) – is assumed to last 14 days in all disease scenarios, after which is assumed that the pig walks into a healthy stage again (Figure 11). Furthermore, particular disease occurrence suggests that the scenarios will differ from each other in regards with the main production performances that are important for the farm profitability (Table 7). These are: the average daily gain, the feed conversion ratio, the mortality rate, the average meat price (and the discount carcass, where applicable), the time the disease occurs, the antibiotic for treatment and its acquired withdrawal period, the production days in total for reaching the finishing unit, etc.

5.3.1. Scenario 1: Basic situation (BS)

In this scenario, a situation without extra involvement/development of diseases is considered. The average values involved in estimation of the production costs are taken from literature and most recent reports on costs for finishing pigs in Netherlands. Also, the average values on daily growth rate and feed conversion ratio have been used in the calculation of the average production days and average slaughter weight (Figure 11).

5.3.2. Scenario 2 - Enzootic Pneumonia (EP 28) and Scenario 4 - Arthritis (A 28) with time of occurrence 28 days (4 weeks) before slaughter

In these scenarios confirmed infection with Enzootic Pneumonia (Scenario 2) and confirmed Arthritis infection (Scenario 4) with prescribed 7 days antibiotic treatment with Tetracyclines and Tiamulin are considered, respectively. These scenarios share the same time-fold of infection occurrence - the infection is detected 4 weeks (28 days) before delivery to the slaughterhouse, meaning that from the time of introducing of the pig into the fattening farm the pig is healthy and is gaining weight with the average 0.772 kg/day (Figure 11).

5.3.3. Scenario 3: Enzootic Pneumonia (EP 14) and Scenario 5: Arthritis (A 14) infection with time of occurrence 2 weeks (14 days) before slaughter

In these scenarios confirmed infections with Enzootic Pneumonia with prescribed 7 days antibiotic treatment (Tetracyclines) and Arthritis infection with 7 days of antibiotic treatment (Tiamulin) are considered. These scenarios share the same time-fold of infection occurrence - the infection is detected 2 weeks (14 days) before delivery to the slaughterhouse (Figure 11).

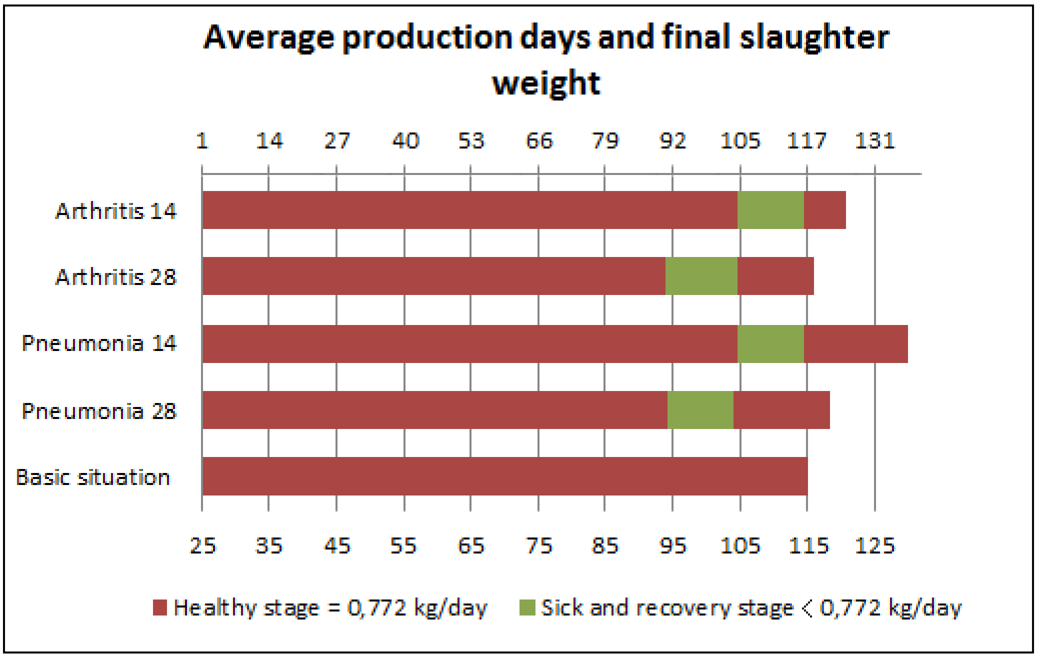


Figure 11: Average production days and final slaughter weight according to each scenario (upper axis shows time/days; bottom axis shows average slaughter weight kg/pig)

5.3. List of relevant external factors

As it became clear from the previous section the line of factors considered for the scenario analysis are the time of disease occurrence and the duration of the required periods with respect to the used antibiotics for treatment. The event of these particular factors would lead to influencing the main production parameters which results in various effects over the economic situation of a hog farmer and mainly on the farm profitability. In Table 7 are summarized and shown the relevant economic factors according to each scenario. An elaborated reasoning on the selected factors is preceded.

Table 7: List of relevant external factors

	units	Scenario 1 (BS)	Scenario 2 (EP 28)	Scenario 3 (EP 14)	Scenario 4 (A 28)	Scenario 5 (A 14)
Antibiotic treatment	7 days/type	none	Tetracyclines	Tetracyclines	Tiamulin	Tiamulin
Withdrawal periods	(days)	none	30	30	14	14
Average daily growth	(kg/day)	0,772	0,562	0,562	0,731	0,731
Feed conversion ratio	(kg feed/kg pig)	2,78	3,08	3,08	2,78	2,78
End weight when complied[3]	(kg/pig)	115	119	130	115	120
Selling price when complied	(€/kg)	1,52	1,44	1,37	1,52	1,44
End weight when not complied[4]	(kg/pig)	115	115	115	115	115
Selling price when complied	(€/kg)	1,52	1,52	1,52	1,52	1,52
Average production days when complied[4]	(days)	117	126	140	117	124
Average production days when not complied[4]	(days)	n/a	120	120	117	117
Mortality rate when treated	(%)	2,5	9,23	9,23	7	7
Mortality rate when not treated	(%)	n/a	20	20	14	14
Probability infection to spread when not treated	(%)	n/a	60	40	60	40
Probability of inspection	(%)	0,05	0,05	0,05	0,05	0,05
Probability of detection when not complied	(%)	n/a	70	99	70	70

[3] The calculation order of the average production days and average slaughter weight in times of compliance and non-compliance according to the scenarios can be found in Appendix I.

5.3.1. Average life span of a hog and the factor of "critical" time occurrence of a disease

With the exclusion of prophylaxis antibiotics, the normative situation introduces a specific period of time during which the animals will achieve the optimum slaughter weight (OSW). Normally, pigs are delivered at about 25 kg of weight (starting weight). The average growth rate of Dutch hogs is 0.772 kg/day (Fowler, 2007). At the age of approximately 117 days and a weight of 115 kilograms the hogs are ready to be slaughtered[4]. Therefore, the net weight referred as OSW will be set to 115 kg. Overall, the average production days to reach the OSW are dependent on the average daily growth and feed conversion ratio of the animals. The average daily growth can be reduced in result of disease which can cause increased number of the production days if it is not treated. However, if treated also increased production days can be expected due to the mandatory withdrawal periods. Ultimately, if the average production days are more than the average of 117 days, it would have impact on the annual net profit. In Figure 13 can be seen a graphic presentation of the 'time windows' which were considered (point A and point B) to enhance different decision outcomes.

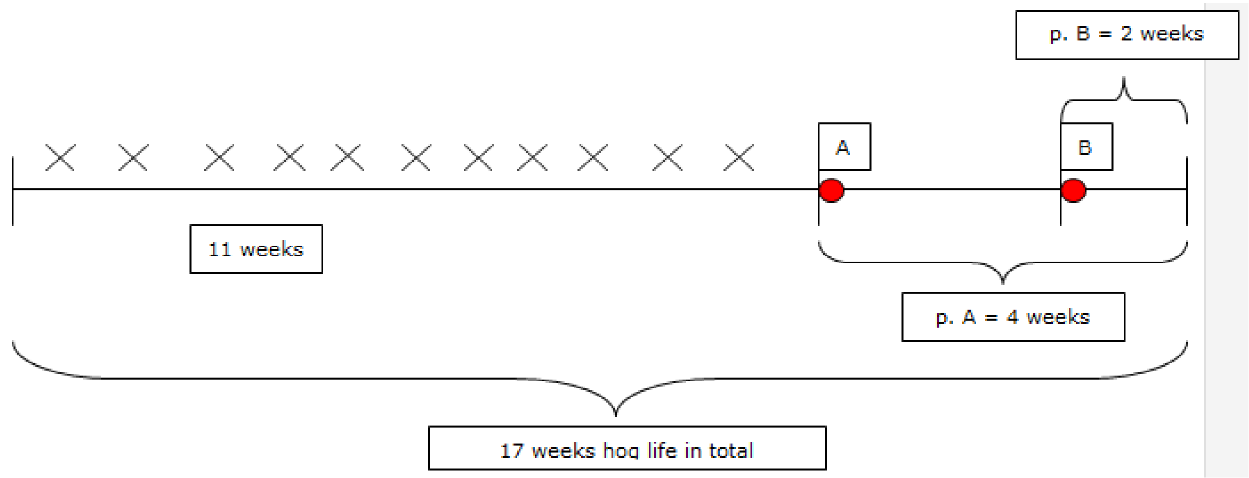


Figure 12: Graphic presentation on the factor of critical time of compliance

5.3.2. Selected diseases and correspondent therapeutic antibiotics in finishing pigs

In Chapter 2.4 two diseases of importance for the scenario analysis were studied. The search and selection of the diseases was primarily based on the likelihood of occurrence in late stage of production. Literature studies on hog diseases showed that depending on the age, the animal is more susceptible to

[4] If OSW = 115 kg and the starting weight is 25 kg, then 115 kg – 25 kg = 90 kg that the hog should gain at the farm. If the average daily gain is 0.772 kg/day, then 90/0.772 = 116.5 ≈ 117 days to reach the OSW.

develop one kind of disease and less susceptible to develop another, e.g. young pigs are more susceptible to gastric infections than joints infections (Jensen, 2008; Escobar et al., 2002). Furthermore, on the basis of the observed reduced production performances of the animals due to the diseases, the diseases were categorized as a severe (Enzootic Pneumonia) treated with antibiotics from the groups of Tetracyclines (waiting period of 30 days) and a mild (Arthritis) infection treated with Tiamulin (waiting period of 14 days) (see Table 2: Selected diseases which occur most often in hogs).

- ***Prevalence of the disease to spread, if "no treatment"***

The study in Chapter 2 suggests also that the prevalence of both diseases can be more than 50% in hog herds (Maes et al., 1998; Jensen, 2008). Hence, when there is a disease with an onset '28 days before slaughter', this would mean that the animals will spend longer time (compared to disease with an onset '14 days before slaughter') at the farm without being treated. This is considered to predispose higher chance of the disease to spread. For these reasons, probability of 60% 'not treated and spread' is assumed. Following the same reasoning, the probability a disease to spread with an onset '14 days before slaughter' is then 40% 'not treated and spread'. These assumptions apply to the decision is "not to treat" in the decision tree model.

In order to quantify the potential losses for "no treatment", higher mortality rate were assumed. The average mortality rate in Dutch hog farms is 2.5% (Fowler, 2009). The average mortality rate in case of Enzootic Pneumonia is 9.23% and the average mortality rate in case of Arthritis infection is 7% (as discussed in Chapter 2). In addition, in Chapter 2 was already studied worst case scenario for Enzootic Pneumonia where it has been reported that the mortality rate can reach 20% (Maes et al., 1996). The same rate is in the calculations of decision "not to treat" Enzootic Pneumonia. Due to insufficient literature on the mortality rate of Arthritis in case of "no treatment" the value of 14% mortality rate was used for the calculations.

5.3.4. Likelihood of inspection

It is known that 90% of the hog farms in Netherlands belong to IKB-quality assurance programs, for which each farm will be inspected at least 2 times per year (Danish Agriculture & Food Council, 2008). According to Directive No (EC) 96/23/, 0.05% of the pigs slaughtered in the previous year will yield the number of pigs that must be controlled for all kinds of residues and substances (Directive 96/23/EC). Hence, in the Decision Tree Modelling the inspection frequency of 0.05% per farm will be taken into account. The main reason why the inspection frequency on residues of allowed antimicrobial substances is that residues of VMPs, listed in Directive 96/23/EC, are classified as Category 2 which means that they are considered as low or negligible potential concern due to the low toxicological profile of the residues of these compounds.

5.3.5. Likelihood of detection

In case of non-compliance the probability of detection is assumed to be dependent on the time the batch has been delivered before the withdrawal period has been completed. Considering that the maximum withdrawal days are 30 days, a 3-stage probability of detection is assumed. When the animals are delivered and violation is posed, the basic principle of assumption follows the logic that the earlier before the waiting period is completed, the higher the probability of detection would be (Table 8):

Table 8: Probabilities of detection related to the uncompleted days of withdrawal

Days before withdrawal period is completed	Probability of detection
From 1 to 9 days	70%
From 10 to 19 days	80%
From 20 to 30 days	99%

5.3.6. Weekly market price for hogs

Market price (€) per kg carcass weight – it is an important economic factor since market weight can influence the meat quality as well as the profit in swine production (Kim et al., 2005). Although, the accepted optimal slaughter weight of a hog is 115 kg, the farmer will receive money for his product per 90 kg hot carcass weight (Hoste and Bondt, 2006). In the Netherlands cold carcass is neither used for pricing nor for sampling inspection, since the blood is drained, the meat is cooled and already cut in pieces (Fowler, 2009) .In pig production, the prices are set on a weekly basis, which is seen as an important external factor that could influence the farmers' decision. A research on the monthly prices for the years of 2009 to 2013 was performed. Information via an Irish company (Board Bia)[5], which regularly updates prices for pork meat in Netherlands, was used to estimate the average price for the calculations of the net profit per delivered pig. In Figure 13 can be seen the price trends over the years of 2009 to 2013. By taking each value from every month in every year, it was estimated the average pig price of €1.52 kg carcass hot weight, with maximum sell price of €1.69 and minimum sell price of €1.34.

[5] http://www.bordbia.ie/industryservices/information/pig/pages/default.aspx

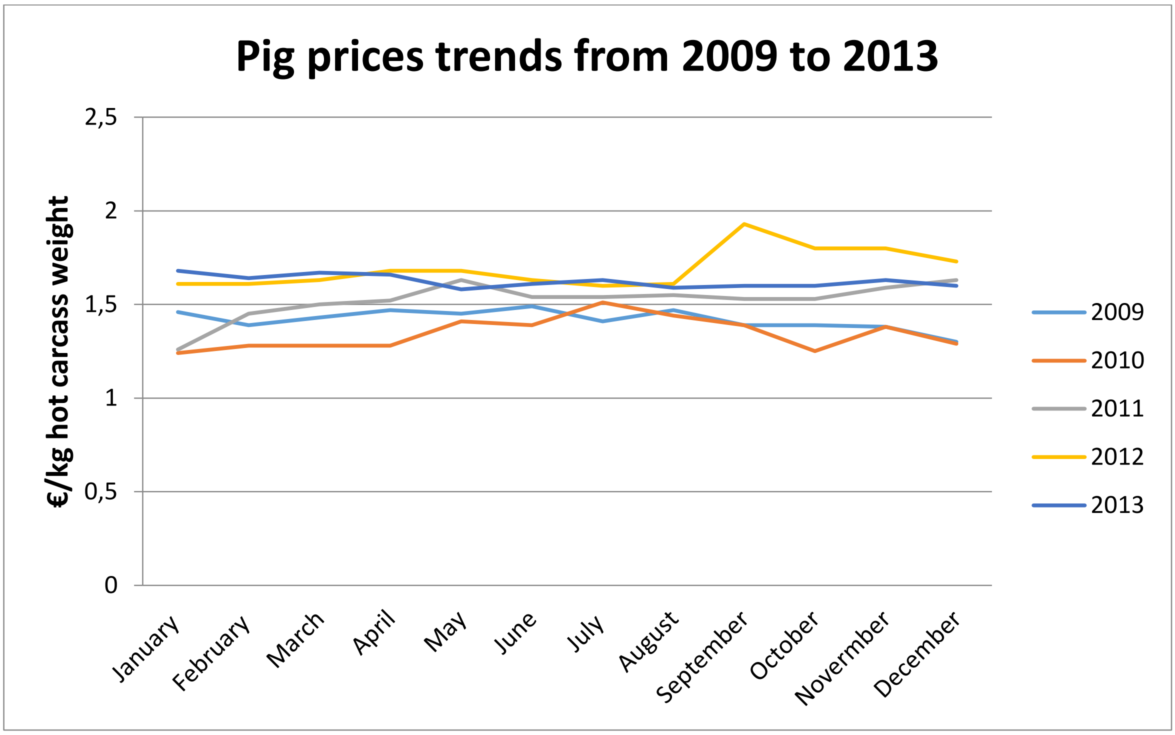


Figure 13: Pig prices trends from years 2009 to 2013

Since the meat prices basically determine the net profit of the farmer (total gross revenue minus total costs) it is expected that price differences will have an impact on the likelihood of compliance with withdrawal periods. In addition, if the delivered animals exceed 115 kg at the slaughterhouse, the producers' price varies from the current set at the time, since the meat is not considered lean anymore and the meat quality is reduced. The reduction of the price in this case will help to calculate the potential losses which can be considered when compliance with the withdrawal periods is considered. Therefore, a quality carcass discount on the set price must be considered in order to calculate the average net profit per delivered when compliance is involved. Hence, assumptions in case of meat quality are:

- In cases where the optimum slaughter weight of the delivered batch is between 115 to 120 kg the quality carcass discount is 5% off the standard slaughter price. If the average standard meat price is €1.52 kg carcass weight, then 5% discounted meat price would be €1.44 kg carcass weight.
- Furthermore, it was assumed that if the animals exceed more than 120 kg the discount is 10% off the standard producers' price. Hence, the discounted meat price would be €1.37 kg carcass weight.

5.4. Calculation model to estimate payoffs in accordance to the scenarios

Measurement costs have been considered to explain the choice of compliance decision. For this purpose in existing Farm model built in Excel were calculated (Anonymous, 2013):

- The costs of the disease versus the benefits of the treatment;
- The costs per withdrawal (cost of compliance) versus the benefits of non-compliance.

Since the total costs per delivered pig can vary in accordance to the size of the delivered batch, three farm sizes from each batch upon arrival in the slaughter house were considered. In addition, the size of the average net profit per delivered batch is also considered as cost/benefit consideration in compliance behavior because the size of the severity sanction can be higher than the profit, which can change the farmer's intention "not to comply".

The majority of Dutch farms are housing around 900 pigs/farm and several hundred of them have more than 2000 pigs/farm (Kemp et al., 2011). Hence, in the calculation model of this thesis, the average of 900 and 2000 pigs/farm will be used, resulting in ap. 1500 pigs/average size farm. Each farm is assumed to have three separate departments where pigs are housed. All-in-all-out (AIAO) production systems are well-known and studied to yield the best health, feed efficiency, weight gain and money saving outcomes (Scheidt et al., 1995). In addition, the practice is that when several animals are infected all pigs are treated aiming to reduce the chance of inspection spread. Based on all this, decisions will be made considering the whole department if/when disease occurs. Therefore, it shall be assumed that one department corresponds to one batch. Thereon, small farm size will deliver 300 pigs/batch, an average farm size – 500 pigs/batch and a large farm size – 660 pigs/batch.

5.4.1. Main inputs for the Farm Model

Table 9 and Table 10 show summary of all related (variable and fixed) production costs per delivered pig, according to small, average and large farm department (batch), divided in 'compliance' and 'non-compliance', 'not treated and spread' and 'not treated and not spread', respectively.

a) Feed costs

The feeding costs in commercial pork production yield more than half of all production expenses (Lange, 1999). Overall, feed costs along with the prices of piglets account the two main cost factors in the fattening production (European Commission, 2009). In 2006, Hoste estimated that an average feed package of 100 kg costs 17.6 euros (Hoste and Bondt, 2006). It should be noted that in times of infection the feed costs may vary since the feed conversion is higher. In order to estimate the feed costs per pig, the farm model uses the following formula:

$$(1)\ Average\ growth\ per\ pig\ (kg) \times Feed\ conversion\ \times \left(\frac{Feed\ price}{100\ (kg)}\right)$$

Table 9: Summarized costs per delivered pig - Basic situation, Scenario 2, 3, 4 and 5 of compliance and non-compliance (€/delivered pig)

Scenarios	Basic situation			Scenario 2 (EP 28)						Scenario 3 (EP 14)						Scenario 4 (A 28)						Scenario 5 (A 14)					
What if				complied			not complied			complied			not complied			complied			not complied			complied			not complied		
	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large
Piglet cost	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
Feed costs	44	44	44	51	51	51	49	49	49	57	57	57	49	49	49	44	44	44	44	44	44	46	46	46	44	44	44
Housing costs	1.6	1.6	1.6	2.4	2.4	2.4	2.3	2.3	2.3	2.7	2.7	2.7	2.3	2.3	2.3	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.7	1.7	1.7
Interest livestock, land, feed and cash	1.7	1.6	1.5	2.7	2.5	2.5	2.6	2.4	2.3	3.2	3.0	2.9	2.6	2.4	2.3	1.8	1.7	1.7	1.8	1.7	1.7	1.9	1.8	1.8	1.8	1.7	1.7
Health care	1.9	1.9	1.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Failure	2.3	2.2	2.2	11	9.8	9.5	10	9.6	9.4	11	10	10	10	9.6	9.4	7.0	6.6	6.5	7.0	6.6	6.5	7.2	6.8	6.6	7.0	6.6	6.5
Delivery costs	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Transport	13	7.7	5.9	19	11	8.6	18	11	8.3	21	13	9.6	18	11	8.3	14	8.3	6.3	14	8.3	6.3	15	8.8	6.6	14	8.3	6.3
Other costs	9	9	9	14	14	14	13	13	13	16	16	16	13	13	13	10	10	10	10	10	10	11	11	11	10	10	10
Labour	12	12	12	14	14	14	14	14	14	16	16	16	14	14	14	14	14	14	14	14	14	15	15	15	14	14	14

Table 10: Summarized costs per delivered pig for basic situation, each scenario of not treat and not spread / not treat and spread (€/delivered pig)

Scenarios	Basic situation			Scenario 2 (EP 28)						Scenario 3 (EP 14)						Scenario 4 (A 28)						Scenario 5 (A 14)					
What if				not treated & not spread			not treated & spread			treated & not spread			treated & spread			not treated & not spread			not treated & spread			not treated & not spread			not treated & spread		
	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large	small	average	large
Piglet cost	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
Feed costs	44	44	44	49	49	49	49	49	49	49	49	49	49	49	49	44	44	44	44	44	44	44	44	44	44	44	44
Housing costs	1.6	1.6	1.6	2.0	2.0	2.0	2.4	2.4	2.4	2.3	2.3	2.3	2.4	2.4	2.4	1.7	1.7	1.7	1.8	1.8	1.8	1.7	1.7	1.7	1.8	1.8	1.8
Interest livestock, land, feed and cash	1.7	1.6	1.5	2.6	2.4	2.3	2.7	2.5	2.5	2.6	2.4	2.3	2.7	2.5	2.5	1.8	1.7	1.7	1.9	1.8	1.7	1.8	1.7	1.7	1.9	1.8	1.7
Health care	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Failure	2.3	2.2	2.2	10	9.6	9.3	26	24	23	10	9.6	9.3	26	24	23	7.0	6.6	6.4	15	14	14	7.0	6.6	6.4	15	14	14
Delivery costs	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Transport	13	7.7	5.9	18	11	8.3	19	11	8.7	18	11	8.3	19	11	8.7	14	8.3	6.3	14	8.6	6.5	14	8.3	6.3	14	8.6	6.5
Other costs	9.5	9.5	9.5	13	13	13	14	14	14	13	13	13	14	14	14	10	10	10	11	11	11	10	10	10	11	11	11
Labour	12	12	12	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14

b) Piglet cost

The weaning and the fattening period of a hog are done at different specialized for the specific activity farms. Therefore, farmers need to purchase piglets for their fattening farms. The set price of €51 per piglet, as taken from the most recent data is used (Hoste, 2011).

c) Heath care

With regards to health care cost it was difficult to find reliable data. The value for the basic situation is taken from a previous study on production costs in fattening farms and set to €1.90 (Anonymous, 2013). Furthermore, it is reported that during diseases increased veterinary costs and medicines can be observed, this can be mainly due to the fact that efficient treatment includes administering injections, medicated feed and water and individual handling of the infected pigs (increased labour costs) (Burch, 2007; The Pig Site, 2014). Therefore, for the disease scenarios €3 for health care cost per pig is assumed.

d) Labour hours per year

Labour costs in The Netherlands, Denmark and the U.S. is around 22 euros/hour (Hoste, 2013). In order the labour costs per pig to be estimated, the following equation is used in the built-in Farm Model:

$$(2)\ \frac{\left(\frac{Hours\ per\ year \times Labour\ wage\ per\ hour}{Number\ of\ pigs}\right)}{Rate\ of\ turnover\ corr.\ per\ death}$$

- ***Rate of turnover***

Rate of turnover (Table 11) is a measurement of the number of times pigs are sold in a time period of one year or the number of rounds a farm will deliver to the slaughterhouse:

$$(3)\ Rate\ of\ turnover\ = \frac{(365\ days\ per\ year \times Average\ growth\ per\ day)}{Average\ growth\ per\ pig}$$

Hence, the average production days to reach OSW dictate the rate of turnover of the farm. Or, when the daily growth is reduced due to infections also the numbers of production cycles are reduced due to the increased production days. However, the rate of turnover is necessary to be corrected accordingly to the mortality rate. Although, the duration of the production stays the same, so the rounds stay in the same ratio, the correction for death indicates the reduced number of delivered pigs. More importantly, rate of turnover corrected for death must be used when calculating the variable costs, such as labour, transport costs, housing costs, etc. Therefore, the rate of turnover corrected for death is computed by:

$$(4) Rate\ of\ turover\ corrected\ for\ death = \frac{\{Rate\ of\ turnover\ \times\ [OSW - (\frac{Mortality\ rate}{2})]\}}{OSW}$$

Table 11: Calculated rate of turnover (#/year) and rate of turn over correct for death (#/year) for each scenario and possible decision

Scenarios	What if	Rate of turnover	Rate of turnover (corr. death)
Scenario 1 Basic situation	n/a	3.12	3,09
Scenario 2 (Enzooric Pneumonia 28)	treated & complied	2.18	2,09
	treated & not complied	2.27	2,18
	not treated & not spread	2.27	2,18
	not treated & spread	2.27	2,07
Scenario 3 (Enzooric Pneumonia 14)	treated & complied	1.95	1,88
	treated & not complied	2.27	2,18
	not treated & not spread	2.27	2,18
	not treated & spread	2.27	2,07
Scenario 4 (Arthritis 28)	treated & complied	2.95	2,86
	treated & not complied	2.95	2,86
	not treated & not spread	2.95	2,86
	not treated & spread	2.95	2,77
Scenario 5 (Arthritis 14)	treated & complied	2.81	2,72
	treated & not complied	2.95	2,86
	not treated & not spread	2.95	2,86
	not treated & spread	2.95	2,77

- ***Calculation of the needed labour hours per year***

It is estimated that 6 to 7 hours are needed for each ton slaughtered weight. This is the weight gained at the sight of the fattening farm and not the OSW, since the fattening pigs start from 25 kg live weight. Therefore, the labour hours are expected to change mainly in dependence with the rate of turnover (corrected for death), the size of the batch and the weight gained at the farm.

$$(5) \frac{Number\ of\ pigs\ in\ a\ batch\ \times rate\ of\ turnover\ (corr.death) \times weight\ gained\ in\ the\ farm}{1000\ (kg)}\ x\ 6\ hours$$

In addition, due to occurrence of disease in the herd, an additional hour for surveillance, care and treatment was included as an extra labour in Scenarios 2 to 5. Hence, the formula will include multiplying by 7 hours. In Table 12 can be seen the calculated hours per year in times of compliance and non-compliance. It should be noticed that in time of compliance the required hours are higher compared to those in time of non-compliance, for which the main reason is the observed overweight during the waiting periods.

- ***Calculation of the gained weight at the farm***

Two main objectives for these calculations are included – the gained weight in case of compliance and the gained weight in case of non-compliance. Noted, the gained weight in case of non-compliance should be the same as in case of the basic situation; hence, the gained weight at the farm shall not exceed more than 90 kg/pig. In case of compliance, the values from Table 7 were used in order to calculate the average gained weight in the farm:

$$(6)\ \left(End\ weight\ when\ complied\ (kg) - Optimum\ slaughter\ weight\ (115\ kg)\right) + average\ gained\ weight\ (90\ kg) = gained\ weight\ in\ the\ farm\ when\ complied\ (kg\ per\ delivered\ pig)$$

Table 12: Calculated labour (hours/year) in all scenarios for all considered batch sizes

	Average gained weight		Small size farm/batch (300 pigs/batch)				Average size farm/batch (500 pigs/batch)				Large size farm/batch (660 pigs/batch)			
	When complied	When not complied	Labour (complied)	Labour (not complied)	Labour (not treated & not spread)	Labour (not treated & spread)	Labour (complied)	Labour (not complied)	Labour (not treated & not spread)	Labour (not treated & spread)	Labour (complied)	Labour (not complied)	Labour (not treated & not spread)	Labour (not treated & spread)
units	kg/pig	kg/pig	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year	hours/ year
Scenario 1 (no disease)	90	90	502	n/a	n/a	n/a	834	n/a	n/a	n/a	1104	n/a	n/a	n/a
Scenario 2 (EP 28)	94	90	413	412	412	391	687	686	686	652	908	906	906	860
Scenario 3 (EP 14)	105	90	414	412	412	391	690	686	686	652	911	906	906	860
Scenario 4 (A 28)	90	90	540	540	540	523	900	900	900	872	1189	1189	1189	1151
Scenario 5 (A 14)	95	90	542	540	540	523	904	900	900	872	1193	1189	1189	1189

e) Transport costs

Every week piglet will be brought to the farm. The calculated costs for this are: 52 weeks * 2.5 hours * €0.75 per hour = €3120 (Anonymous, 2013). The work load is calculated on the basis of: 370 (hours) * €22 the (hourly wage) = €8140. The transport risk is calculated by: 13 (transported piglets) * €51 (piglet cost) = €663. The SUM will result in transport expenses for a whole year, which are fixed costs. However, in order to calculate the transport costs to bring piglets is done by: number of pigs (which varies from one farm size to another) * the rate of turnover (which generally varies from one scenario to another).

Then, in order to calculate the transport costs per delivered pig, the year transport costs are divided by the total costs to bring piglets. From Table 9 and Table 10 can be seen that these varies from one farm size to another because the number of finished pigs differs (where most favourable price is for large farm sizes).

f) Other costs

The inputs for 'Other costs' are taken from literature (Hoste, 2011), all shown in Table 13. Estimation of the 'other costs' per delivered pig is done by dividing the total other costs per year and the rate of turnover corrected for death.

Table 13: Other fixed costs

Costs	€
Water	0.5
Heating Bedding	0.7
Electricity Telephone Insurance Memberships	1.1
Taxes Car Other costs	11.9
Manure costs	15
Total/year	29.2

g) Interest livestock, land, feed and cash

Land, feed and cash are fixed costs = €8.34. The depreciation rate is considered 50%. The interest rate is assumed of 0.5%. Interest livestock + land, feed and cash are assumed fixed costs and are calculated as follows:

$$(7)\ \Big((Piglet\ price + 0.5 \times (Health\ care\ costs + Feed\ costs\ per\ delivered\ pig + Other\ costs\ per\ delivered\ pig) + Transpoer\ costs\ per\ delivered\ pig) + land, feed\ and\ cash\ costs\ per\ delivered\ pif\Big) \times 0.05$$

Chapter 6

Results

6.1. Annual Net Profits via Farm Model

Table 14 shows the average gross revenue per delivered pig (average kg carcass weight times the average meat price €/kg carcass weight) and the total production costs. Then, the net profit per delivered pig is the gross revenue per delivered pig minus the total costs per delivered pig. Further, in Table 15 are presented the average net profit that one house department yields for one year, according to small, average and large farm size. The production costs per delivered pig are calculated with the included failure rate, interest paid, taxes paid and the corrected rate of turnover for death. Hence, all the expanses have been taken out as the kill-out factor has been included and what remains is the average net profit per delivered pig. Therefore, the average total net profit per year is calculated by:

(8) $Annual\ net\ profit = \ Pigs\ per\ batch\ \times Rate\ of\ turnover \times Average\ net\ profit\ per\ delivered\ pig$

What can be noticed in Table 15 is that a small size farm generates not a Net Profit but a Net Loss or a Negative Net Profit. Since the operating costs remain overall the same when compared to the average and large farm size, the one possible and most logical reason for such result is the lack of sales that a small size house department has per year. Hence, the numbers of bought, fattened and sold pigs do not generate enough income to pay for building costs, electricity, delivery, transport cost and so on. This brings to the realization that a small size farm that has three housing departments and each department yields 300pigs/batch is not a realistic assumption and will be excluded from the decision tree analysis.

Table 14: Average gross revenue (€/delivered pig), total costs (€/delivered pig), average net profit (€/delivered pig), for each scenario and each possible decision choice

	What if		Total costs	Average gross ravenue	Net profit
Basic situation	n/a	small	138.40	137.26	-1.14
		average	132.90	137.26	4.36
		large	131.00	137.26	6.26
Scenario 2 (EP 28)	complied	small	170.00	130.00	-40.00
		average	160.60	130.00	-30.60
		large	157.90	130.00	-27.90
	not complied	small	164.80	137.26	-27.54
		average	157.20	137.26	-19.94
		large	154.20	137.26	-16.94
	not treated & not spread	small	163.40	137.26	-26.14
		average	155.80	137.26	-18.54
		large	152.70	137.26	-15.44
	not treated & spread	small	181.90	137.26	-44.64
		average	171.70	137.26	-34.44
		large	168.40	137.26	-31.14
Scenario 3 (E 14)	complied	small	182.80	123.71	-59.09
		average	173.60	123.71	-49.89
		large	170.10	123.71	-46.39
	not complied	small	164.80	137.26	-27.54
		average	157.20	137.26	-19.94
		large	154.07	137.26	-16.81
	treated & not spread	small	163.70	137.26	-26.44
		average	156.10	137.26	-18.84
		large	153.00	137.26	-15.74
	treated & spread	small	181.90	137.26	-44.64
		average	171.70	137.26	-34.44
		large	168.40	137.26	-31.14
Scenario 4 (A 28)	complied	small	148.58	137.26	-11.32
		average	142.51	137.26	-5.25
		large	140.32	137.26	-3.06
	not complied	small	148.58	137.26	-11.32
		average	142.51	137.26	-5.25
		large	140.32	137.26	-3.06
	not treated & not spread	small	147.42	137.26	-10.16
		average	141.36	137.26	-4.10
		large	139.16	137.26	-1.90
	not treated & spread	small	156.57	137.26	-19.31
		average	149.81	137.26	-12.55
		large	147.35	137.26	-10.09
Scenario 5 (A 14)	complied	small	153.29	130.00	-23.29
		average	146.91	130.00	-16.91
		large	144.58	130.00	-14.58
	not complied	small	148.58	137.26	-11.32
		average	142.51	137.26	-5.25
		large	140.32	137.26	-3.06
	not treated & not spread	small	147.42	137.26	-10.16
		average	141.36	137.26	-4.10
		large	139.16	137.26	-1.90
	not treated & spread	small	156.57	137.26	-19.31
		average	149.81	137.26	-12.55
		large	147.80	137.26	-10.54

Table 15: Annual Net Profit (€/year)

Scenario	What if	Small farm	Average farm size	Large farm size
Basic situation	n/a	-1,071	6,795	12,882
Scenario 2 (EP 28)	treated & complied	-26,160	-33,354	-40,143
	treated & not complied	-18,755	-22,632	-25,380
	not treated & not spread	-17,801	-21,043	-23,132
	not treated & spread	-30,400	-39,089	-46,654
Scenario 3 (EP 14)	treated & complied	-34,568	-48,643	-59,704
	treated & not complied	-18,755	-22,632	-25,188
	not treated & not spread	-18,006	-21,383	-23,582
	not treated & spread	-30,400	-39,089	-46,654
Scenario 4 (A 28)	treated & complied	-10,034	-7,762	-6,059
	treated & not complied	-10,034	-7,762	-6,059
	not treated & not spread	-9,014	-6,061	-3,779
	not treated & spread	-17,120	-18,544	-19,979
Scenario 5 (A 14)	treated & complied	-19,594	-23,702	-28,814
	treated & not complied	-10,034	-7,762	-6,059
	not treated & not spread	-9,014	-6,061	-3,779
	not treated & spread	-17,120	-18,544	-20,883

6.2. Decision Tree Analysis

The analyses involve construction of decision trees which give visual representation of the flow of events in a logical and time-ordered progression for each created scenario. The decision trees are based on whether to treat or not to treat with antibiotics when a disease occurs. The basis of deciding, if treated, is should the farmer comply or not with the required withdrawal periods. Since the probability of inspections is known and the probability of detections has been assumed, the decision making is under certain risk. Therefore, for each decision the EMV must be calculated. Using the EMV suggests that the farmer is risk neutral and the selected decision is based on the best expected payoff. This is done by the expected value criterion, in other words defying the EMV.

$$(15)\ EMV = \sum(Probability)(Payoff)$$

The payoff for each scenario is calculated by using Scenario 1 (Basic situation – optimal production performance) as a baseline. Thereof, the calculated payoffs are the value of Δ Annual Net Profit; hence, the relative profit compared to the baseline. In Table 17 and Table 18 represent the payoff tables for average and large farm, respectively. As can be seen, the results of EMV from the decision tree analyses (Appendix 2) showed that in each case scenario, except Scenario 4 (A 28), non-compliance will appear. Penalties, inspection fees and consequences (Table 16) were considered as follows:

- Consequence I: penalty fee and warning. For an inspection fee is assumed 1 hour ante-mortem inspection which accounts of €104 (€26 for every 15 minute ante-mortem inspection, Table 5, Chapter 3). However, in case of non-compliance and detection additional €78 for ante-mortem sampling is included together with €7800 official penalty fee regarding misused withdrawal periods.
- Consequence II: exclusion from the IKB Pigs quality scheme for a minimum of one year. This would mean that the farmer will lose his license to trade with slaughterhouses. The potential losses are quantified by taking the Total Annual Net Profit from the Basic Situation (BS).
  - Calculations of "Consequence II" - for an average size farm the average Net Profit per year is €5,910 per house department, where for a large size farm the average Net Profit per year is €11,300 per department. It is said that each farm, no matter the size, has three house departments. Then, the average Net Profit per year/department is multiplied by 3 to result in the average Net Profit for all three house departments, or in other words the average Net Profit per farm/year, respectively €17,730 and €33,901. Hence, these will be the considered potential losses if a farmer is excluded from the IKB scheme programs for minimum of one year.

Table 16: Related penalties and considered inspection fees

	Compliance	Non-compliance
Consequence I	n/a	€7800
Consequence II	n/a	€17,730 (average farm size) €33,901 (large farm size)
Inspection fee	€104	€104 + €78

Table 17: Payoff table for all scenarios with the estimated EMV for average farm size (the red marked cells presents the altered decision choices)

Scenario 2 (EP 28) - average farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-40 253	-40 149	n/a	n/a	n/a	n/a	n/a	-40 149
Treat and not comply	no detection	-29 427	-37 409	n/a	-29 531	n/a	n/a	-29 430 (I)
	no detection	-29 427	n/a	-47 339	-29 531	n/a	n/a	-29 433 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-45 884	-27 838	-38 666
Probabilities	0.0005	0.9995	0.70		0.30	0.60	0.40	

Scenario 3 (EP 14) - average farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-55 542	-55 438	n/a	n/a	n/a	n/a	n/a	-55 438
Treat and not comply	no detection	-29 427	-37 409	n/a	-29 531	n/a	n/a	-29 431 (I)
	no detection	-29 427	n/a	-47 339	-29 531	n/a	n/a	-29 436 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-45 884	-28 178	-35 260
Probabilities	0.0005	0.9995	0.99		0.01	0.4	0.6	

Scenario 4 (A 28) - average farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-14 661	-14 557	n/a	n/a	n/a	n/a	n/a	-14 542
Treat and not comply	no detection	-14 557	-22 539	n/a	-14 661	n/a	n/a	-14 560 (I)
	no detection	-14 557	n/a	-32 469	-14 661	n/a	n/a	-14 563 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-25 339	-12 856	-20 346
Probabilities	0.0005	0.9995	0.7		0.3	0.6	0.4	

Scenario 5 (A 14) - average farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-30 601	-30 497	n/a	n/a	n/a	n/a	n/a	-30 397
Treat and not comply	no detection	-14 557	-22 539	n/a	-14 661	n/a	n/a	-14 560 (I)
	no detection	-14 556	n/a	-32 469	-14 661	n/a	n/a	-14 563 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-25 339	-12 856	-17 849
Probabilities	0.0005	0.9995	0.7		0.3	0.4	0.6	

Table 18: Payoff table for all scenarios with the estimated EMV for large farm size (the red marked cell presents the decision choice based on the lowest negative expected payoff)

Scenario 2 (EP 28) - large farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-53 129	-53 025	n/a	n/a	n/a	n/a	n/a	-53 025
Treat and not comply	no detection	-38 262	-46 244	n/a	-38 366	n/a	n/a	-38 265 (I)
	no detection	-38 262	n/a	-72 354	-38 366	n/a	n/a	-38 274 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-59 536	-36 014	-50 127
Probabilities	0.0005	0.9995	0.70		0.30	0.60	0.40	

Scenario 3 (EP 14) - large farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-72 690	-72 586	n/a	n/a	n/a	n/a	n/a	-53 025
Treat and not comply	no detection	-38 080	-46 052	n/a	-38 174	n/a	n/a	38 074 (I)
	no detection	-38 080	n/a	-71 153	-38 174	n/a	n/a	-38 087 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-59 536	-36 464	-50 127
Probabilities	0.0005	0.9995	0.99		0.01	0.4	0.6	

Scenario 4 (A 28) - large farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-19 045	-18 941	n/a	n/a	n/a	n/a	n/a	-18 941
Treat and not comply	no detection	-18 941	-26 923	n/a	-19 045	n/a	n/a	18 944 (I)
	no detection	-18 941	n/a	-53 024	-19 045	n/a	n/a	-18 953 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-32 861	-16 661	-26 381
Probabilities	0.0005	0.9995	0.7		0.3	0.6	0.4	

Scenario 5 (A 14) - large farm								
Decisions	State of Nature							EMV
			Detection					
	Inspection	No inspection	Detection (I)	Detection (II)	No detection	Spread	No spread	
Treat and comply	-41 800	-41 696	n/a	n/a	n/a	n/a	n/a	-41 696
Treat and not comply	no detection	-18 941	-26 923	n/a	-19 045	n/a	n/a	-18 944 (I)
	no detection	-18 941	n/a	-36 853	-19 045	n/a	n/a	-18 947 (II)
Not treat	n/a	n/a	n/a	n/a	n/a	-33 675	-16 661	-23 503
Probabilities	0.0005	0.9995	0.7		0.3	0.4	0.6	

However, if the expected payoffs from compliance and non-compliance are taken from the decision tree analyses (Appendix 2) and the probability of inspection is utterly ignored, the in Table 19 can be observed that the severity of sanction can change the decision. From this table can also be seen that if the disease occurs prior closest slaughter period and if the farmer decides to treat then, in all cases he will be less willing to comply with the withdrawal periods, since even the heaviest penalty (Consequence II –

exclusion from IKB for minimum of one year; hence, losing his license to produce) is not able to compensate for the decision to comply.

Table 19: Summarized EMV for compliance and non-compliance when the risk factor of inspection is ignored

	Consequence	Compliance (EMV)	Non-compliance (EMV)
Scenario 2 (EP 28)	(I)	- €40 149	- €35 046
	(II)	- €40 149	- €41 997
Scenario 3 (EP 14)	(I)	- €55 438	- €37 330
	(II)	- €55 438	- €47 161
Scenario 4 (A 28)	(I)	- €14 542	- €20 176
	(II)	- €14 542	- €27 128
Scenario 5 (A 14)	(I)	- €30 497	- €20 176
	(II)	- €30 497	- €27 127

Furthermore, if it is expected that the probability of inspection is 100%, so the farmer can be sure that his farm will be inspected, the question of what the fine has to be so that the farmer shall comply given these scenarios. In this case, the difference between the net loss between compliance and non-compliance would give the value of the actual fine so that, if a farmer is risk neutral, it would not matter whether he complies or not. Hence, in Table 20 is shown the break-even points of how high the penalty must be when the risk of inspection is perceived as certain. As can be seen there would be no need of penalty in case of Scenario 4 since there is no difference between compliance and non-compliance, due to the fact that the disease is mild and only lightly affects the production performance of the animals when infected. Additionally, the disease is with an onset of 28 days before slaughter which gives enough time for the withdrawal period to be completed without prolonging the delivery time of the batch. These penalty fees suggest that one possible enforcement strategy is increase the penalty fees along with the frequency of inspections so that compliance to be accomplished in any case. However, such enforcement strategies are not likely to be feasible having in mind the priority settings of antibiotics residues from Group B1.

Table 20: Penalty fees in case of certain (100% probability) inspection (€)

	Average farm	**Large farm**
Scenario 2 (EP 28)	10 722	14 763
Scenario 3 (EP 14)	26 011	34 516
Scenario 4 (A 28)	0	0
Scenario 5 (A 14)	15 940	22 755

When the risk of inspection is taken into account it does not matter what is the difference between Consequence I and Consequence II, how big is the penalty fee, due to the fact that the risk of inspection is so small (0.0005 which means that 5 in 10 000 samples, or 1 in 2000 will be detected). Hence, this kind of risk factor is able to diminish any accounted difference in severity of penalties which in result can enhance non-compliance. It is logical that this kind of analyses would alter the best optimal decision (based on the lowest negative payoff) since estimating the EMV suggests that the decision-maker is risk neutral. In addition, the analysed situations are repeating themselves in a long turn where the farmer's only aim is profit maximization. If this holds true, then break-even points regarding penalty fees can be calculated (Table 21). In Table 21 can be noticed that the break-even points vary from one scenario to another and

Table 21: Break-even points regarding payoffs and probabilities for all scenarios[6]

Break-even points	**unit**	**Scenario 2**		**Scenario 3**		**Scenario 4**		**Scenario 5**	
		Average farm	Large farm	Average farm	Large farm	Averag e farm	Large farm	Average farm	Large farm
Payoff (penalty)	€	21,473,530	29,622,000	52,051,427	69,070,070	14,661	18,941	31,894,557	45,528,941
Probability (inspection)	%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Payoff (not spread)	€	4,758	6,380	18,470	-23,788	-1,654	-1,940	7,378	9,068
Probability (not spread)	%	91	90	93	93	86	86	86	87

also from one farm size to another. Penalties that amount millions of euros, with the given probability of inspection, would result in the same EMV for compliance and non-compliance alternatives. However, these kinds of penalties are neither realistic, nor feasible, given the nature of the crime. Thereon, such estimated enlargement of the penalties that aims to enhance compliance with withdrawal periods cannot be accepted as relevant. In addition, if the majority of disease situations will lead to non-compliance due to negligible inspection probability and low penalty fees compared to the gains if not complied, then the expected non-compliance rate in Dutch finishing pigs regarding MRLs would be much higher than the reported 1.2% (EFSA, 2011b). In addition, the calculations on the break-even points regarding probabilities of inspection suggested that the alternatives whether to comply or not to comply are so far away from each other that there is no actual probability value that would yield the same EMV regarding compliance and no compliance. Further, the question how often the analysed situations occur in real-life and how many of these 1.2% can actually be referred to that presents major uncertainty. Hence, even though the probabilities of inspections are known, the lack of certain validity of the developed disease scenarios (and their severity of impacts) poses questions on the certainty of events. The calculation of the break-even points regarding probabilities the disease not to spread indicates that a farmer would chose not to treat if on average these particular diseases have a certainty of not spreading close to 90%. In addition, when the break-even

[6] Calculation of the break-even points can be found in Appendix 2

payoffs(not spread) are calculated it becomes clear that the same ones has to be ac. twice as less as originally estimated in order EMV(treat) to be equal to the EMV(not treat). Here it is important to be realised that the calculations of the disease scenarios included the worst case, assuming that the animals are sick through the whole lifetime at the farm and not during the particular timeline according to the scenarios' set-up. Thereon, it is logical that the production costs when the disease is not treated will be much higher if compared to the baseline while, in fact, it should account a lot shorter period of disease time which should result in lower production costs.

In order research questions No. 9 to be answered, the difference between the baseline and each disease scenario (treated and not complied) in the labour and management income was used for estimating the costs of treating hogs. The farmer's salary for their labour and management efforts is expressed in the labour and management income (Table 22). Hence, the labour and management income is calculated by the SUM of the labour costs (Table 9 and Table 10) and the net return per delivered pig (Table 14). In order to find answers on research question No. 10 the differences in labour and management income between complied and not complied alternatives were used (see Table 23). As can be seen in Table 23, the costs per treatment are dependent on the severity of the disease, while the costs per withdrawal depend also on the time of the disease have occurred. Hence, if the disease occurs closer to the finishing unit the more expensive it is to withdrawal the animals after the treatment. Furthermore, compared to the baseline the costs of withdrawal are much higher than the costs of treatment the disease, with exception to Arthritis in 28 days before slaughter – then, no difference between treatment and compliance is observed, neither in non-compliance. In addition for all other scenarios, in Table 22, a significant difference between compliance and non-compliance can be observed. Moreover, it should be notices that the figures corresponding to non-compliance does not change between Enzootic Pneumonia with onset 14 and 28 days and the same applies for Arthritis with onset 14 and 28 days. This is because the delivery of the animals is performed as soon as the animals have reached the optimum slaughter weight. In result of which no delays in the delivery are expected, nor overweight have been reached that would compromise the selling price and further which also can affect the rate of turnover. The latter is expected to be higher compared to cases of compliance and in fact is higher, see Table 11. The same principle applies for the figures corresponding to the rest "What if" decisions and their similarities.

In conclusion, the economic analyses suggested that the best option is not to comply with the withdrawal periods in order to avoid higher net losses when disease occurs. Furthermore, the Farm model showed that the losses are higher if the disease occurs closer to the slaughter period which in all analysed situations will enhance non-compliance, no matter if the disease is severe or mild and if the required withdrawal period is short or long. Therefore, it can be concluded that given the performed analyses the regulation regarding compliance with the withdrawal periods pose negative impact on the farm profitability and if profit maximization is aimed, then non-compliance shall occur in 3 out of 4 cases. The only case that makes exception, in fact, is the one that practically do not show any difference in the profit between compliance and non-compliance (Scenario 3, Arthritis 28 days).

Table 22: Labour and management income of the owner-operator (€/delivered pig)

What if	Scenario 1 Baseline		Scenario 2 Pneumonia 28 days		Scenario 3 Pneumonia 14 days		Scenario 4 Arthritis 28 days		Scenario 5 Arthritis 14 days	
	average farm size	large farm size	average farm size	large farm size	average farm size	large farm size	average farm size	large farm size	average farm size	large farm size
no disease	15,68	17,63	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Treated & complied	n/a	n/a	-16,88	-13,77	-33,36	-29,88	8,57	10,77	-2,27	0,05
Treated & not complied	n/a	n/a	-6,24	-3,26	-6,24	-3,26	8,57	10,77	8,57	10,77
Not treated & not spread	n/a	n/a	-5,07	-2,09	-5,07	-2,09	9,72	11,93	9,72	11,93
Not treated & spread	n/a	n/a	-20,76	-17,21	-20,76	-17,21	1,28	3,74	1,28	3,74

Table 23: Calculated costs for treatment of disease and costs per withdrawal of antibiotics (€/delivered pig)

	Treat[7]		**Withdrawal**[8]	
	average farm size	large farm size	average farm size	large farm size
Pneumonia 28 days	-21,92	-20,89	-32,56	-31,4
Arthritis 28 days	-7,11	-6,86	-7,11	-6,86
Pneumonia 14 days	-21,92	-20,89	-49,04	-47,51
Arthritis 14 days	-7,11	-6,86	-17,95	-17,58

[7] Cost of treatment = labour and management income (treated & not complied) - labour and management income (baseline)

[8] Cost of withdrawal = labour and management income (treated & complied) - labour and management income (baseline)

Chapter 7

Discussion and conclusion

The aim of this research was to gain insight on the factors that influence the compliance behaviour of Dutch pig farmers with the European legislation in terms of antibiotics use. For this purpose three main objectives on the topic have been covered in the attempt to better understand the incentives and probable obstacle one to obey or ignore the law regarding withdrawal periods, in particular, Council Directive 2001/82/EC of 6 November 2001 on the Community code relating to veterinary medicinal products. The first pillar of the research was built on the ground of literature study on antibiotics, animal diseases in finishing pigs attended for human consumption and the related treatment alternatives and the involved withdrawal periods when antibiotics are applied. Therefore, research questions as 'How are antibiotics defined?', 'Which illnesses occur most frequently at pig farms and which antibiotics are mainly used to treat these diseases?' and 'What is a "withdrawal period" and why is it mandatory?' were addressed. In the following paragraphs each question will be answered referring to the performed literature study of this thesis. The main reason of finding answers to these questions was to provide sufficient background information that enabled creating relevant disease scenarios with their according treatments and acquired withdrawal periods in finishing pigs in order economic cost/benefit analyses to be performed.

How are antibiotics defined?

Antibiotics are specific antimicrobial substances that have the potency to kill, or inhibit the growth of, microorganisms, including both bacteria and fungi. They are seen as economical feasible and efficient ways to treat and prevent diseases in livestock. Antibiotics are natural metabolic processes of the fungi and algae and when extracted and applied to pathogenic bacteria or protozoa the cells get destroyed and the microorganisms die. Thereon, in nature all living microorganisms have the ability to overcome antibiotics by developing resistance against these metabolites. However, numerous scientific researches reveal that the increased and mass usage of antibiotics in human and animals has led to development of more resistant bacteria causing annually thousands of death cases in the society and economic losses of billions of euros, as described in Chapter 2, p. 9. For this manner, the European Union recognised the need that the use of antibiotics has to be limited and minimized as much as possible, especially in animal husbandry since several of antibiotics used in livestock are also used in human medicine.

Which illnesses occur most frequently at pig farms and which antibiotics are mainly used to treat these diseases?

The adopted system to monitor antibiotic use in Dutch food producing animals is called MARAN, via which the provided recent reports helped in tracing the antibiotics that are mostly used in Dutch hog farms. Based on this information a literature study enabled the isolation of two most common diseases that are treated accordingly to the used antibiotics and particularly these diseases which have susceptible period in older finishing pigs. At the end, the two most common groups of antibiotics that are used in Dutch hog farmers are those from the group of Tetracyclines and Macrolides. According to the study research, Chapter 2, these antibiotics are mainly used for treating and preventing respiratory bacterial infections, gastrointestinal infections, infectious diseases of locomotive organs, skin bacterial infection, infectious diseases of genito-urinary tract, sepsis, etc. However, the literature showed that pigs can be more susceptible to one disease and less likely to be infected with another depending on their age and weight. Therefore, Enzootic Pneumonia and Arthritis in hogs were the selected diseases with therapeutic antibiotics from the group of Tetracyclines and Macrolides, accordingly.

What is a "withdrawal period" and why is it mandatory?

A withdrawal period refers to the time that passes between the last dose administered to the animal and the time when the level of residues in the tissues, milk or eggs are lower than, or equal to, the MRL (Dir. (EC) No 82/2001, Article 1(9)). The primary purpose of establishing MRLs is to ensure the protection of the consumer against possible harmful effects resulting from exposure to residues. It is considered that ensuring compliance to the established MRLs, hence compliance with the required withdrawal periods, the adverse effects of antibiotics can be avoided, such as carcinogenicity, hepatotoxicit, allergies, etc.

What are the basic legal requirements to a pig farmer with respect to antibiotics and with respect to good business practices?

According to the GFL, a Dutch hog farmer is seen as a "food business operator" because he is in charge with the breeding pigs intended for human consumption and bringing of food commodity in the form of pig meat. For these purposes, the hog farmer is forced to bring to the market safe products and if/when in times he fails to do so he must initiate a procedure to withdraw the compromised animals immediately. In regards with antibiotics, not safe or unfit for human consumption product would be animals delivered with higher than the legally established MRLs, or in other words, if the farmer is aware or in any doubt that he failed to apply the required withdrawal periods he should not sell his animals until they are safe to be slaughtered. Therefore, in order this information to be kept in track, which animals have been sick, treated, delayed in slaughter, etc., the GFL lays down the principle of traceability, for which each animal has to bear a health mark or an identification mark, further adopted in Regulation 853/2004, part of the 'hygiene package', according to which all food stakeholders shall have HACCP systems in place in order to maintain a high level of public health. Furthermore, 90% of the pig farmers participate and are certified by IKB quality scheme which further provides a guarantee about the methods of production which have proved to be very important for maintaining consumer's trust in the meat production sector. Moreover, the legal person to prescribe antibiotics, treat and examine animals in the holding is the approved veterinarian who must be authorised from the competent authority. Hence, in order to prevent misuse of antibiotics only authorised person ("the veterinarian and/or the livestock owner or other authorized person") can prescribe, whether for treatment or prophylaxis, antibiotics and records. The latter need to contain information regarding the animal's health status, the antibiotics that were administered to the animal and the withdrawal period of the substance (Reg. 853/2004, Annex II, Section III, 3(b)(c)). A good practice is to have a signed certificate from a veterinarian that states "he or she examined the animals at the holding and found them to be healthy" (Reg. 853/2004, Annex II, Section III, 7(a)). In this case, the farmer is liberated from the "24 hours rule upon slaughter" and can provide the needed information at the time of arrival of the animals in the slaughterhouse. Hence, slaughterhouse operators are forbidden to accept animals onto their premises if the latter is not met.

Which are the enforcement strategies currently applied and what is the mechanism which national authorities have installed to check on pig farmers?

In the Netherlands, the established official competent authority is the Dutch Food and Consumer Product Safety Authority (NVWA) which is an independent agency in the Ministry of Economic Affairs and a delivery agency for the Ministry of Health, Welfare and Sports. As such, it monitors food commodities based on monitoring programmes and yearly established plans approved by the European Union in order to safeguard the public health, animal health and welfare. Hence, the NVWA is the official responsible body for collecting the data and sending the results of the surveys which take place each year under the supervision of the Commission. Thereon, meat inspections are needed in order to minimize the risk of humans becoming exposed to microbiological and/or chemical hazards and to serve in achieving the mentioned above legal requirements. In other words, the purposes of inspections are to evaluate whether or not the commodities are fit for human consumption. Meat inspections can be two type ante-mortem and post-mortem. However, only by gathering samples from the animals can be established whether the animals contain higher than the legal acquired MRLs in the blood and edible tissues. Since sampling can be very expensive and time consuming, the sampling plans are made correspondent to the current production systems and age of the animals. The collected samples must account at least 0.05% of the total number of animals slaughtered per year because "the numerical basis for calculation of the value of 0.05% is the number of slaughtered animals reported in the previous year" (EFSA, 2011). Inspections are carried out by the competent authorities without any prior notice. Fattening farms are rather homogenous in animal population and age (being slaughtered at a younger age) and generally those farms must have operational protocols based on HACCP and with Food Chain Information (FCI) data. For these reasons, in the context of exposure to contaminants and tissue residues, fattening farms are considered with a low-risk profile. In addition, establishing IKB quality schemes improved the focus of the meat inspections which are performed explicitly on the basis of exchanged FCI available at the slaughterhouse prior to slaughter. This system allows creating of risk profiles (risk based meat inspections) at farm level with respect to a certain set of performance standards that have to be met. Or else, the primary reason FCI data to be implemented is to provide appropriate and detailed information on the pre-history, as well as ante-mortem inspection findings. Thus, upon arrival at the slaughterhouse the marketed pigs, intended for slaughter, to be easily and accordingly categorised into higher or lower potential risk groups based on the provided information, in specific "Epidemiological intelligence (data from herd health plans, monitoring/surveillance, medicine and veterinary treatments)".

What can be the consequences for a pig farmer if one is caught in violation against the law?

With regards to antibiotics and their withdrawal periods, a violation is considered as committed, when the MRLs are exceeding from the legally established MRLs. The first step is the competent authority to carry out an investigation should be carried out on the premises of the farm of the origin or departure, in order to determine the reason why the levels have been exceeded (Dir. 96/23/EC, Article 18(1)). In accordance to the reason, the competent authorities will take measures to protect public health which may include "prohibiting animals from leaving the farm concerned or products from leaving the farm or establishment concerned for a set period" (Dir. 96/23/EC, Article 18(1)).

Consequence I: If the suspicion of violation is justified due to positive samples and in a result of the carried out investigation then the owner of the farm or the person in charge of the animals is obliged <u>to pay the expenses of the analysis</u> (Dir. 96/23/EC, Article 19(1)) (see Table 5).

Consequence II: Farmers who fail to comply with the IKB Pigs assurance system shall face sanctions where the most severe one is exclusion from the scheme for a minimum of one year (ISN, 2004).

Consequence III: If infringements of maximum residues levels are repeatedly reported and products have been placed on the market, no matter that, the competent authorities shall carry out "intensified checks on the animals and products from the farm and/or establishment in question" in the period of six months (Dir. 96/23/EC, Article 18(2)).

Financial Consequences: Farmers who put on the market animals with higher than the legal MRLs are fined in category 3 and must pay the amount of 7800 euro (Staatsblad van het Koninkrijk der Nederlanden, 2012, Artikel 8A.13).

What is 'compliance behaviour' and what is the rate of compliance in terms of antibiotics?

Compliance behaviour is the positive respond and willingness of the individual in response to a given social rule, regulatory requirement, common accepted standard, etc. When someone refuses to follow the rules then non-compliance occurs. There are two possible types of non-compliance behaviour towards any law: incidental mistakes, whether due to lack of knowledge or extend of acceptance of the law in concern, and intentional non-compliance. In regulatory affairs, every detected non-compliance is treated by the law with certain sanctions and these can vary whether the non-compliance is wilful or due to error. Compliance behaviour is key attribute that contributes greatly to the importance and goals achievements of one government and/or public agencies. Conversely, non-compliance can lead to undesirable situations and can cause failure in meeting certain requirements that primary can aim in minimizing hazardous course of events. Often, when one fails to grasp the reasoning behind a given rule, then “forced compliance” could be applied, where the target group is expected not to perform the requested behaviour on their own free will. There are different approaches that have been developed to explain compliance behaviour. This paper dealt with the study on compliance behaviour using Ajzen’s Theory of Planned Behaviour and the developed model of Table of Eleven by the Dutch Ministry of Justice. The latter is based also to one extend on the Ajzen’s theory, therefore by incorporating a study that has focus on both, contributed to better understanding of how and when compliance behaviour occurs. Both, the Theory of Planned Behaviour and the Table of Eleven, suggested that a very important role in the forming of one’s behaviour plays the social peers, whether it is related from social awareness and active participation on “hot topics” to risk of third party reporting or compromising business image within business society, such as IKB-membership. In addition, extrinsic and intrinsic stimuli of compliance behaviour can be equally related and can influence each other which make understanding and studying compliance behaviour rather broad, providing various sides of investigation. Furthermore, other factor of high importance appeared to be the knowledge, education and the respect that the target group show regarding authorities and the imposed rules. In this manner, the rate of non-compliance in the Netherlands regarding veterinary antibiotic substances from group B1, according to the last available EFSA report, is 1.2% non-compliant samples of all taken samples. Given this number it can be considered that the rate of compliance in terms of antibiotics and their required withdrawal periods is very high. In this manner, the low number of non-compliant samples is treated by the authorities as accidental mistakes and not as intentional violation of the law.

Which are the external and internal factors on compliance behaviour?

In this thesis external factors were considered as those factors for which the farmer is not in power to influence or to change unless he does not change his current practices. Ultimately, the accent of the first set of external factors falls on those which are involved according to the regulation in question and the current enforcement strategies. Therefore, investigations on the probabilities of inspections, severity of sanctions, the risk of third party reporting and social awareness, and maintenance of IKB-membership were done. Furthermore, developing disease scenarios enabled the inclusion of particular external factor that is relevant to the situation that was expected to promote non-compliance behaviour - in the face of time pressure or the moment of disease occurrence prior slaughter. From one hand, by the selection of two different diseases (one severe and one mild disease) it was possible to investigate the economic side that the regulation imposes regarding the withdrawal periods, as described in Chapter 3. From another point of view, these scenarios allowed to see the complicated business situation involved with another external factor such as optimum slaughter weight. For these reasons, cost/benefit considerations were also perceived as external factors that can influence the decision to comply or not with the rules, as dealt in Chapter 5. At the same time, internal factors were considered to be those factors for which the farmer relies on his own perception such as: acceptance of the law, motivation, image attitude of his farm, risk perception, knowledge of the rules and past behaviour, as described in Chapter 4.

What are the net costs and benefits on an average scale for treating hogs?

Economic analysis provided a view on the impact of the diseases over the production performance of the animals. Related to that it was observed that the net costs and benefits for treating hogs vary from one disease to another mainly due to the difference in the average daily gain, mortality rate and feed conversion ratio. In order to be estimated the costs per treatment of disease for the two disease scenarios respectively were compared to the baseline scenario which was built on the assumption that it does not include any disease. In result it appeared that the treatment of more severe disease (Enzootic Pneumonia) is almost 3 times more expensive compared to treatment of mild disease (Arthritis), as can be seen in Table 22. The benefits of involved disease treatment are strongly related to the minimization of the mortality rate and the improvement of the average daily growth and feed efficiency of the animals. However, each antibiotic treatment involved certain withdrawal periods which brings the next research question.

What are the net costs and benefits on an average scale per withdrawal?

With regards to the costs that are involved during withdrawal periods, economic analyses showed that these are strongly dependent on the time when the disease is developed. It became evident that when diseases appear closer to slaughter period the costs per withdrawal are much higher due to the involved prolonged time to deliver, in result of which the animals become overweighed and the selling price €/kg is compromised, but also the rate of turnover of the farm is reduced. Another factor that strongly affects the costs per withdrawal is the required days for the withdrawal period of the particular antibiotic.

Is there a countable difference "to comply" or "not to comply"? Or what are the costs and benefits "to comply" or "not to comply"?

In all analysed scenarios, except one (Scenario 4), there is a big difference between compliance and non-compliance with the withdrawal periods. The measurement costs of compliance with references to the analysed scenarios provided the insight that generally the regulation regarding withdrawal periods can affect negatively the farmer's profitability by increasing the production costs and in the same time reducing the selling meat price. The payoffs of compliance vs. non-compliance are strongly related to the time of disease occurrence, the severity of the disease and the duration of the withdrawal periods. The classical decision tree approach assumes that farmers aim profit maximization for which compliance will occur only if EMV to comply is higher than the EMV not to comply. According to the scenario analysis compliance will occur only when it is more beneficial than non-compliance and in this order when the disease does not have so major influence on the production parameters.

How do personal risk profiles and social variables effect the actual decision that is made?

Unfortunately, clear and definite answer to what extend risk profiles and social variable could influence the decision to comply cannot be given since the results of the performed risk analyses (@Risk modelling) are highly doubtful for being performed correctly. Nevertheless, it is known that, in business situations, individuals evaluate the expected outcomes and choose the alternative that would bring the best outcome (Becker, 1968). However, no motives are purely economic or non-economic, although some are more relevant than others for economic behaviour. This is why in some situations one farmer may choose to comply with the withdrawal period even though the benefits are not greater than the costs and generally this decision can be seen as irrational from an economic point of view. An economic model assumes that people perform a decision based on achieving the best possible economic outcome for them. Human behaviour; however, is often not so simple. Rather than acting as ultimate calculating machines, people often tend to make choices that fall short of the greatest possible economic payoff. However, if the results of the economic analyses are held relevant then, the level of non-compliance would be higher than 1.2% out of B1 tested samples in the Netherlands (EFSA, 2011). Therefore, this evidence challenges the obtained results. Either the inspection frequency is so low that cannot efficiently catch the violators or the analysed scenarios do not occur so often or even if they do occur, there are additional and more important attributes to compliance behaviour than these which are purely economic. Behavioural economics explains that there are three main principals why people might prefer a worse economic payoff: concerns about fairness, bounded rationality and risk aversion (Krugman and Wells, 2013). If farmers are risk neutral (as the Decision Tree model suggests) or even risk averse (as most of the literature suggests) then their behavioural intention is not driven on the basis of larger profitability when compliance is acquired. Moreover, according to the scenario analyses even the risk for a farmer to lose his license to produce for minimum one year did not yield change in the decision not to comply due to the low probability of inspection. However, if seen from purely psychological point of view such damage cannot be accepted having in mind that 90% of the Dutch hog farms are sustained family business. Therefore, it cannot be accepted that the danger of losing the family business, the main and most probably only source for family income, would not pose change in the perception of risk and ultimately drive the decision to comply.

In addition, according to the economic results, the main reason why non-compliance would occur is that the risk of inspection and detection is very low. At the same time, the legal research on the objectives of antibiotic residues and the related mandatory withdrawal periods suggested that stringent monitoring for Group B1 antimicrobial substances is not a priority in the risk management program of the European Food Safety Authority. The main reason for this is because first, veterinary medicines have to be authorised by the European Medicine Agency where ADIs and subsequently MRLs have been established with the aim of the safety of the consumer and then, they can be introduced into the market (Directive (EC) No 2001/82, Article 4). In addition, the established quality systems and the integrated stringent traceability systems (FCI prior each slaughter delivery) which are main support for target sampling (monitoring) can be considered as important external (legislative) factors that enhance compliance. Furthermore, if non-compliant samples of this origin are found in the residue monitoring programmes, they are considered as occasional event which does not present a concern to public health (EFSA, 2011). Based on the reported low level of detected non-compliant samples, the Authority determines these as in result of incidental non-compliance behaviour. Hence, due to the high level compliance it can be concluded that hog network (IKB) is well-established and healthy network where the flow of information and the level of fairness between the participants in the group encourages trust and respect towards the competent authorities. Thus, the importance of the cost/benefit considerations cannot be accepted as more important external factor than social influence, remaining good reputation and trust in the competent authorities. Thereon, these external factors can influence in a positive way the attitude towards the requested behaviour. Furthermore, in general, the stereotype or the reputation of the Dutch farmers is subject to good agricultural education and strong work ethics (Frans, 2006). This assumes that Dutch farmers are having positive attitude towards law obedience with the mandatory withdrawal period and they would primarily follow the instructions of the accepted authorities if in return their basic needs are satisfied (Maslow, 1943). Furthermore, the research on how attitudes are formed showed that humans tend to repeat their behaviour once they are committed to the group they belong in and if they are motivated enough. When a person identifies him with reference groups or reference individuals then there is the social identification which is the next determinant of attitude importance (Boninger et al., 1995). Social identification may lead an attitude to become more important to a person if the privileges and rights of the group are perceived to be at risk, as for example the risk of being excluded from the IKB-program which would result in serious obstacles hindering smooth trade. Therefore, participation in IKB-quality schemes can enhance the importance for compliance, perception of fairness and appropriateness of the law and its institutions. Overall, it appears that farmers tend to behave more honest even though this might cause economic losses and factors such as belonging to certain reference group (IKB farmers), social control and acceptance of the law.

Furthermore, the state-of-the-art of the fattening production in Netherlands is one of the most prosperous in Europe which taken on a local scale of knowledge could play an important incentive of motivation for the hog producers to fulfil social norms and expectations of the peer groups. Overall, if a farm is good and strong in producing high quality products with the required characteristics then this enhances the competitiveness of the farm on the market. The competition in the case of pork meat is centred on the quality of the product, on its prices of sale and on the public image of the producer (Selva, 2005). In addition, the fact that there are constant developments and improvements in the feeding programs which can predict lower or higher daily gain should not be neglected. The factor of constant agricultural innovations in high feed quality and improvement on the breeding genetics cannot be rejected to contribute in reducing the losses regarding health and the related production performances. During the development of disease scenario this factor was neglected on purpose because the analyses considered the worst case scenario. However, these optimal and rather pessimistic scenarios may never occur in real-life situations and can be applicable if related to big disease outbreaks.

Finally, the ‘Table of Eleven’ suggests that if one has good knowledge on the rules he could also know how better to violate them without being called. If that person is related with the current network chain, then according to Ford (1992) the chain will be only as strong as its weakest link (Ford, 1992). Based on the gained information on inspection practices it can be concluded that the result of stronger and dependent relationship between the farmer and the veterinarian could occur. Since the monitoring plans can include target-sampling which are mainly based on the received FCI prior slaughter, which can only be filled by the authorised veterinarian, then important question of further investigation is how this flow of events is monitored and assured that the rightful data is presented in the FCI.

Overall, it is difficult to draw a clear line between the external and internal factors of compliance. Even more, it would be wrong to distinguish one from another when both groups of factors can equally influence each other.

Appendix 1

Calculations on the average production days and end slaughter weight in case of compliance and non-compliance with the withdrawal period when animals have been treated

In all scenarios the same pattern of average daily gain is followed – healthy, recovery, healthy. Hence, there are two healthy stages and one recovery in between, assuming that after treatment the animals are healthy again. Healthy stage days means that the animals are gaining weight with the estimated average growth gain of 0.772, where during the days of recovery the animals have an average growth gain according to the infection in question. Although, the healthy stages can vary in days of duration according to the infection onset, withdrawal periods (whether complied or not), the recovery stage is set to 14 days. When an infection occurs 28 or 14 days before slaughter it means that it actually occurs at a specific age of the animal, 89 and 103 days of age. In order the age to be determined, the following formula was used:

$$(1)\ Average\ production\ days\ to\ reach\ finishing\ unit - days\ of\ infection\ occurrence\ before\ slaugh$$
$$= age\ of\ the\ animal\ when\ infection\ starts\ (days)$$

It is necessary the age of the animal to be determined because the approximate weight must be taken into account at the time of the infection's onset. Then, finding the ap. weight (kg) at the time of infection (days) is a matter of multiplying the days by the average growth gain.

$$(2) Age\ of\ the\ animal\ when\ infection\ starts\ (days) \times average\ growth\ rate\ (kg\ per\ day)$$
$$+ 25\ (kg\ starting\ weight)$$
$$= approximate\ hog's\ weight\ when\ infected\ (kg)$$

In order to calculate how much weight the animals gained during the recovery stage, the following formula is used:

$$(3) Ap.\ hog's\ weight\ when\ infected\ (kg) + (14\ days$$
$$\times average\ daily\ gain\ according\ to\ the\ infection\ in\ question\ (kg\ per\ day)$$
$$= ap. hog's\ weight\ at\ the\ end\ of\ recovery\ stage\ (kg)$$

- **Calculations of the average production days when NO compliance with the withdrawal periods is considered**

Due to the reduced daily gain during the recovery stage it is expected that the weight would not reach the optimal slaughter weight of 115 kg. In order to determine the ap. weight necessary to be gained, the following equation is used:

$$(4)\ OSW\ (115\ kg) - ap.hog's\ weight\ at\ the\ end\ of\ recovery\ stage\ (kg) = weight\ needed\ to\ reach\ OSW\,(kg)$$

In order to calculate the needed days to reach the OSW, the following equation is used:

$$(5)\ \frac{Weight\ needed\ to\ reach\ OSW\ (kg)}{0{,}772\ (kg\ per\ day\ average\ daily\ growth\ during\ healthy\ stage)} = days\ needed\ to\ reach\ the\ OSW$$

Finally, in order to estimate the total average production days to reach OSW when certain infection occurs and without complying with the withdrawal periods after antibiotic treatment, a summary on the days of healthy-recovery-healthy cycle is done:

$$(6)\ Age\ of\ the\ animal\ when\ infection\ starts\ (either\ 89\ or\ 103\ days\ of\ age\ as\ determined\ above) + 14\ days\ (recovery\ stage\ as\ determined\ above) + additional\ days\ needed\ to\ reach\ the\ OSW\ during\ second\ healty\ stage\ (equation\ 5) = Average\ production\ days\ when\ not\ complied\ with\ antibiotic\ withdrawal\ periods$$

- **Calculations of the average production days and end slaughter weight when compliance with the withdrawal periods is considered**

When compliance with the withdrawal periods is considered the equation to calculate the average production days and the final slaughter weight at the end of the required waiting periods is performed as following:

In case of 30 (for Tetracyclines) or 14 (for Tiamulin) days withdrawal period:

$$(7)\ \big((Age\ of\ the\ animal\ when\ infection\ starts + (30\ or\ 14\ withdrawal\ days - 7\ days)\big) \times 0{,}772\ kg\ per\ day) + (14\ days\ recovery\ period \times\ average\ daily\ gain\ according\ to\ the\ infection\ in\ question) + 25\ kg\ (starting\ weight) = \ end\ slaughter\ weight\ (kg)\ in\ case\ of\ compliance$$

The reason why 7 days of the official required withdrawal days are subtracted is because the 14 days in recovery stage also include the first 7 days of withdrawal period. Following, if the average production days are to be calculated, then only the involved days in equation (7) must be taken into account and summed.

- **Calculations of the average production days and end slaughter weight when no treatment is considered**

When no treatment is considered the inputs are staying the same as in times of non-compliance. Only the costs for health care are as the average costs as in the basic situation and if the disease spread the mortality rate is higher (see Table 7).

Appendix 2:

Decision trees of the disease scenarios

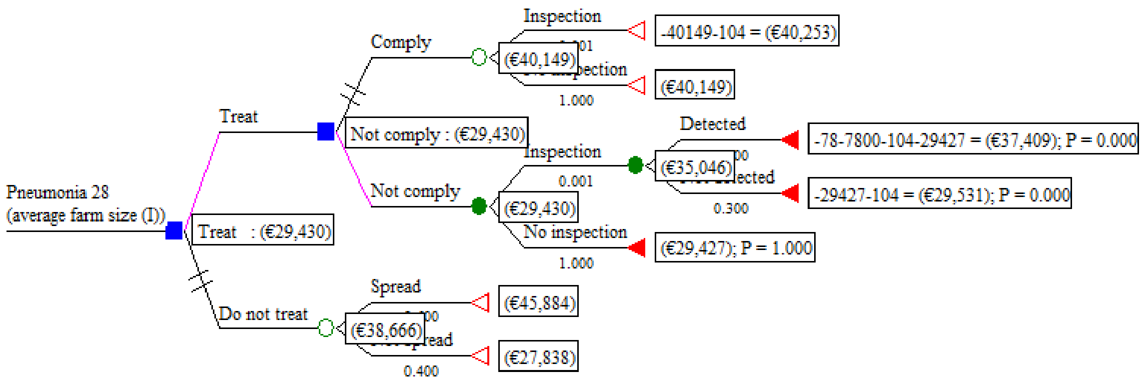


Figure 1: Decision tree of Scenario 2 (EP 28), for average farm department and considered penalty of detection – Consequence I

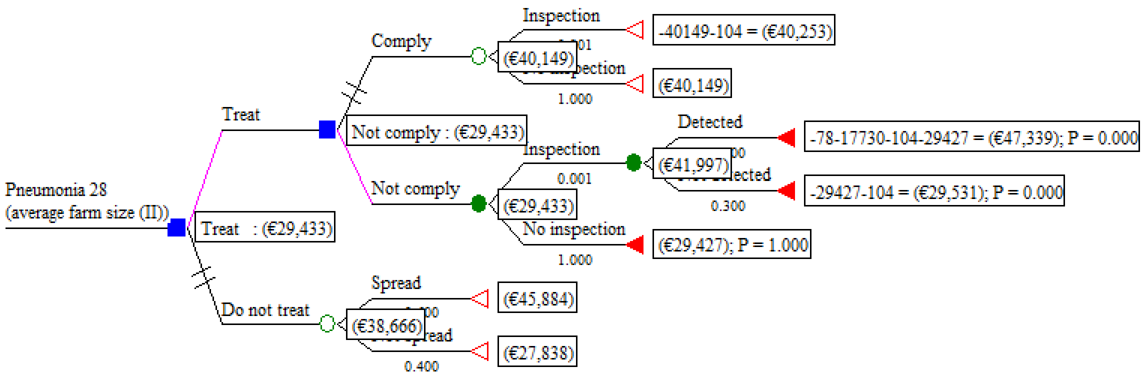


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Figure 2: Decision tree of Scenario 2 (EP 28), for average farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = - €29 433
EMV(not treat) = - (1 – P) * 45 884 + P * (- 27 838) EMV(not treat) = - €29 462
-29 433 = - 45 884 + 45 884p – 27 838p
-18 046p = -16 451
P = 0.91

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = - €29 433
EMV(not treat) = -0.6 * 45 884 + 0.4 * (-Z)
-29 433 = -27 530 – 0.4z
0.4z = 1903
Z = €4758

EMV(compliance) = EMV(no compliance), where the **pay-off(penalty)** is the only unknown **(X)** in EMV(no compliance)
EMV(compliance) = probability(inspection) * pay-off + probability(no inspection) * pay-off = 0.0005 * €40 253 + 0.9995 * €40 149 = €40 149 = €40 149.051
EMV(no compliance) = probability(inspection) * payoff(penalty) + probability(no inspection) * payoff(penalty)
EMV(no compliance) = 0.0005 * x + 0.9995 * €29 427
€40 149.051 = 0.0005x + €29 412.286
-0.0005x = -€40 149.051 + €29 412.286
-0.0005x = - €10 736.765
X = -€10 736.765/-0.0005
X = €21 473 530
EMV(compliance) = €40 149.051
EMV(no compliance) = 0.0005 * €21 473 800 + 0.9995 * €29 427 = €40 149.051

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 40 253 + 0.9995 * 40 149
EMV(no compliance) = Y * 35 046 + (1 – Y) * 29 427
40 149 = 35 046y + 29 427 – 29 427y
- 5619y = -10 722
Y = 1.91, no break-even point regarding probability of inspection

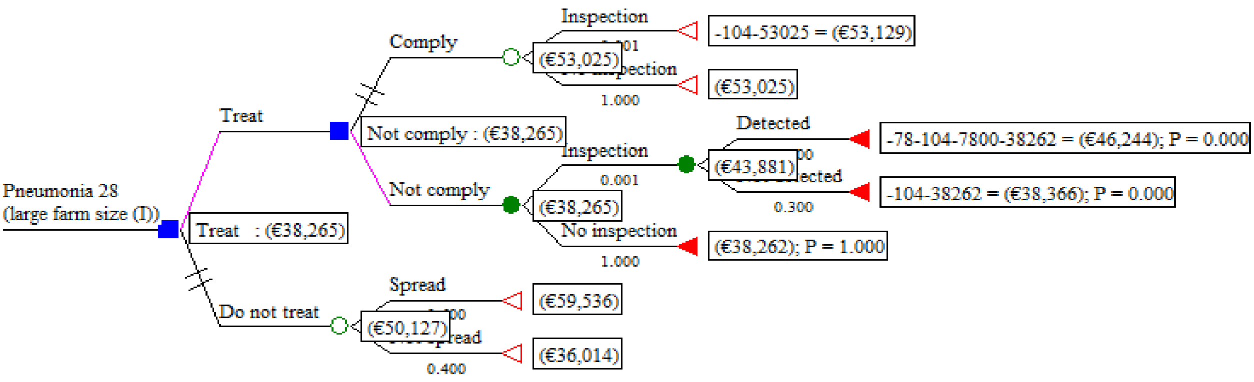

Figure 3: Decision tree of Scenario 2 (EP 28), for large farm department and considered penalty of detection – Consequence I

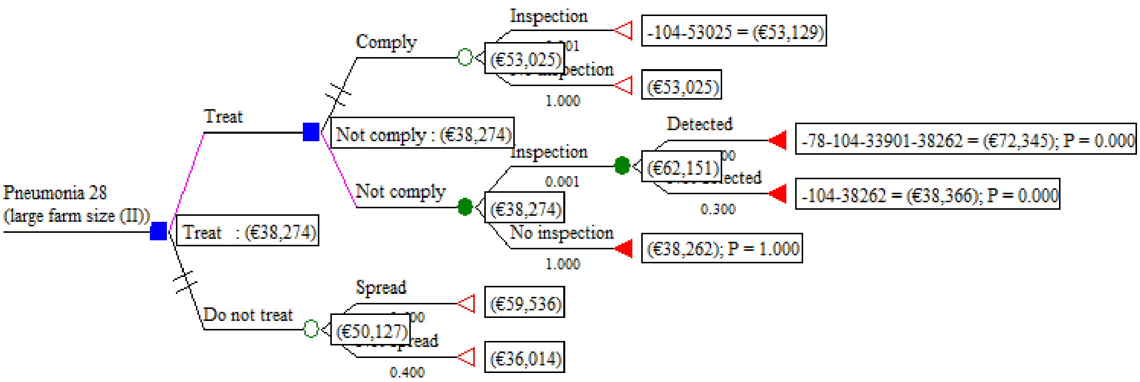

Figure 4: Decision tree of Scenario 2 (EP 28), for large farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = - €38 274
EMV(not treat) = - (1 – P) * 59 536 + P * (-36 014)   EMV(not treat) = -€38 366
-38 274 = -59 536 + 59 536p – 36 014p
- 23 522p = -21 262
P = 0.90

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = - €38 274
EMV(not treat) = -0.60 * 59 536 + 0.4 * (-Z)
-38 274 = -35 722 – 0.4z
0.4z = 2552
Z = €6380

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 53 129 + 0.9995 * 53 025
EMV(no compliance) = 0.0005 * X + 0.9995 x 38 262
53 053 = 0.0005x + 38 242
-0.0005x = -14811
X = €29 622 000 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 53 129 + 0.9995 * 53 025
EMV(no compliance) = Y * 43 881 + (1 – Y) * 38 262
53 053 = 43 881y + 38 262 – 38 262y
-5619y = 14 791
Y = 2.63, no break-even point regarding probability of inspection

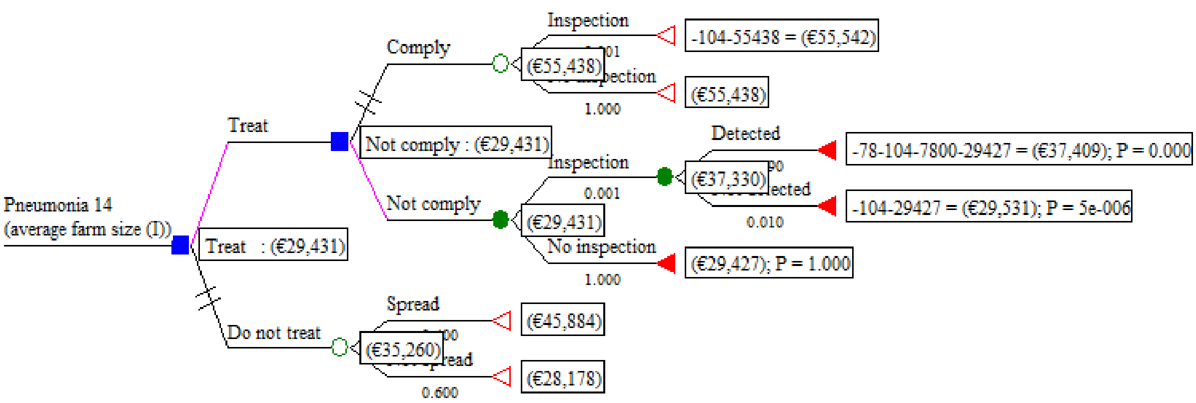

Figure 5: Decision tree of Scenario 3 (EP 14), for average farm department and considered penalty of detection – Consequence I

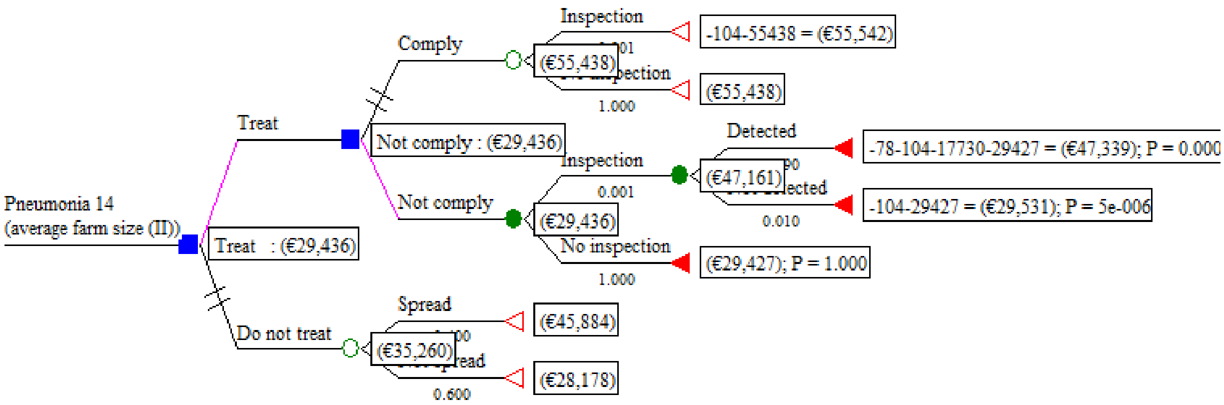

Figure 6: Decision tree of Scenario 3 (EP 14), for average farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = - €29 436
EMV(not treat) = - (1 – P) * 45 884 + P * (-28 178) EMV(not treat) = - €29 417
-29 436 = -45 884 + 45 884p – 28 178p
-17 706p = -16 440
P = 0.93

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = - €29 436
EMV(not treat) = -0.4*45 884 – 0.6 * Z
-29 436 = -18 354 – 0.6z
0.6z = 11 082
Z = €18 470

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 55 542 + 0.9995 * 55 438
EMV(no compliance) = 0.0005 * X + 0.9995 * 29 427
55 438 = 0.0005x + 29 412
-0.0005x = - 26 026
X = €52 051 427 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 55 542 + 0.9995 * 55 438
EMV(no compliance) = Y * 37 330 + (1 – Y) * 29 427
55 438 = 37 330y + 29 427 – 29 427y
- 7903y = 26 011
Y = 3.29, no break-even point regarding probability of inspection

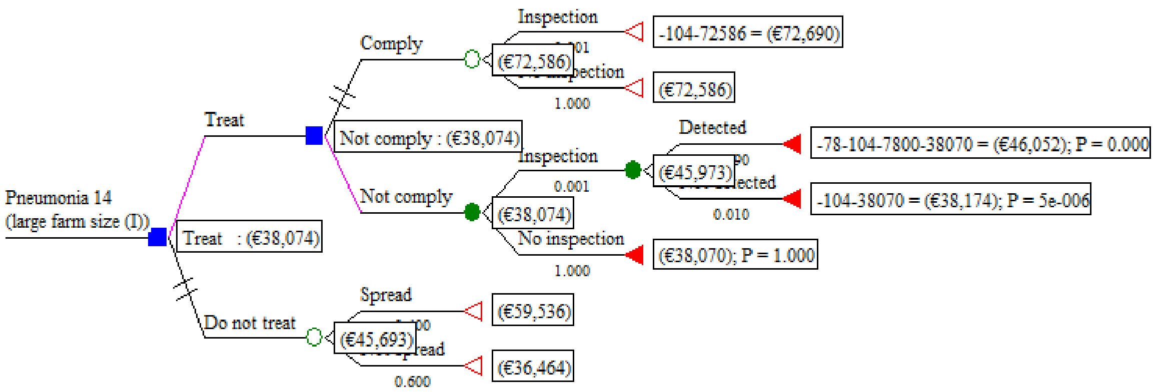

Figure 7: Decision tree of Scenario 3 (EP 14), for large farm department and considered penalty of detection – Consequence I

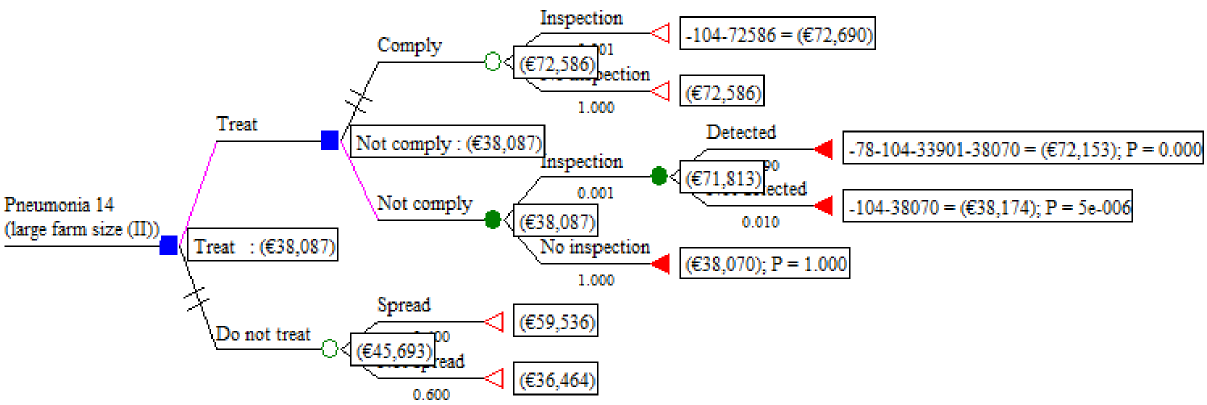

Figure 8: Decision tree of Scenario 3 (EP 14), for large farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = -38 087
EMV(not treat) = - (1 – P) * 59 536 + P * (- 36 464)   EMV(not treat) = -€38 079
-38 087 = -59 536 + 59 536p – 36 464p
-23 072p = - 21 449
P = 0.93

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = -38 087
EMV(not treat) = -0.4 * 59 536 + 0.6 * Z
-38 087 = -23 814 – 0.6z
-0.6z = 14 273
Z = -€23 788

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 72 690 + 0.9995 * 72 586
EMV(no compliance) = 0.0005 * X + 0.9995 *38 070
72 586 = 0.0005x + 38 051

-0.0005x = - 34 535
X = €69 070 070 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 72 690 + 0.9995 * 72 586
EMV(no compliance) = Y * 45 973 + (1 –Y) * 38 070
72 586 = 45 973y + 38 070 – 38 070y
-7903y = -34 516
Y = 4.3, no break-even point regarding probability of inspection

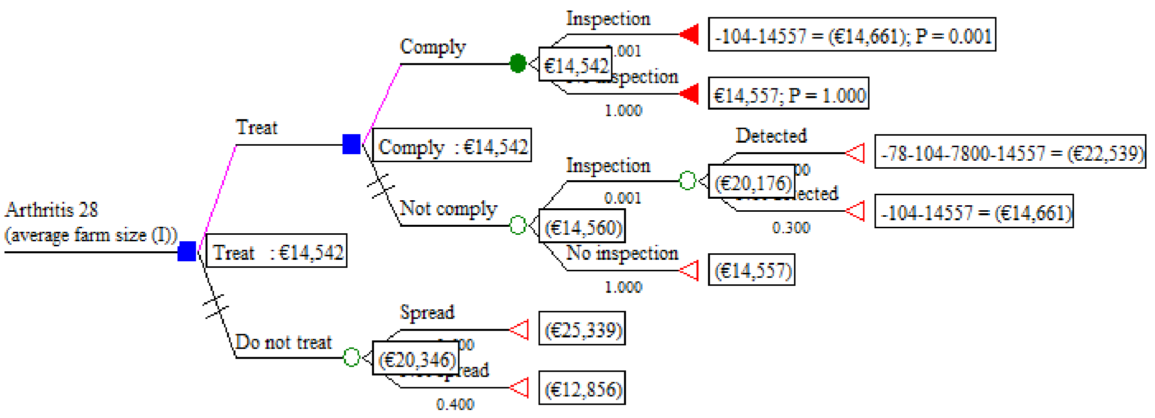

Figure 9: Decision tree of Scenario 4 (A 28), for average farm department and considered penalty of detection – Consequence I

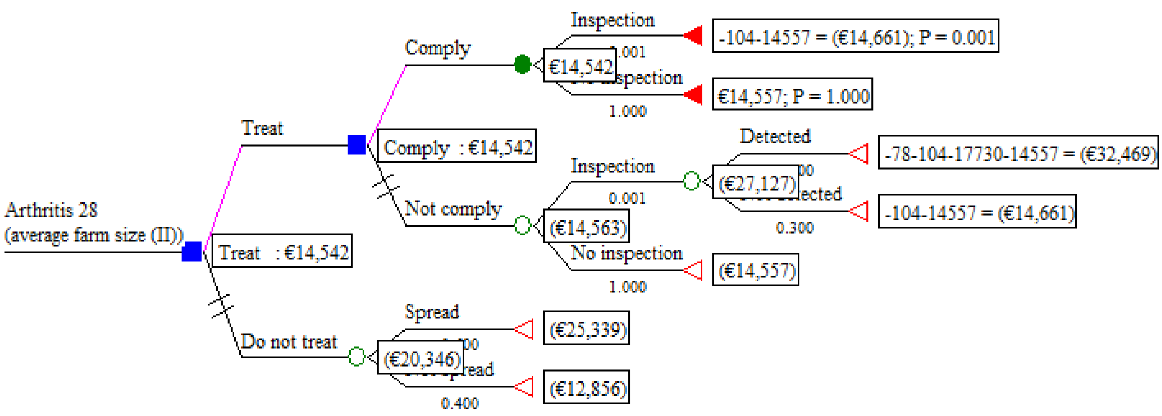

Figure 10: Decision tree of Scenario 4 (A 28), for average farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = -14 542
EMV(not treat) = (1 –P) * -25 339 + P * (-12 856) EMV(not treat) = -€14 604
-14 542 = -25 339 + 25 339p – 12 856p
-12 483p = -10 797
P = 0.86

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = -14 542
EMV(not treat) = -0.6 * 25 339 – 0.4 * Z
-14 542 = -15 203 – 0.4z
0.4z = -661
Z = -€1654

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 14 661 + 0.9995 * 14 557
EMV(no compliance) = 0.0005 * X + 0.9995 * 14 557
14 557.052 = 0.0005x + 14 550
-0.0005x = -7.3305
X = €14 661 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 14 661 + 0.9995 * 14 557
EMV(no compliance) Y * 20 176 + (1 –Y) * 14 557
14 557.052 = 20 176y + 14 557 – 14 557y
-5619y = .052
Y = 9.25, no break-even point regarding probability of inspection

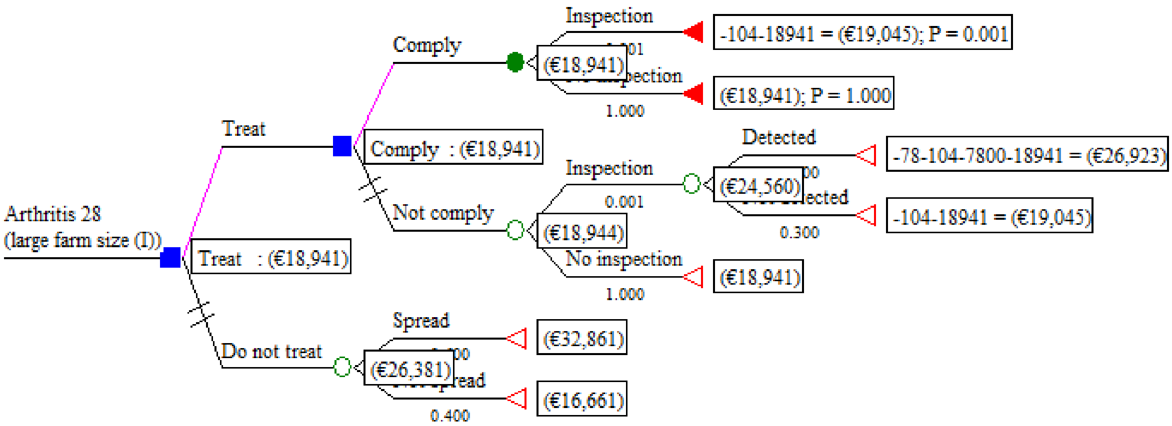

Figure 11: Decision tree of Scenario 4 (A 28), for large farm department and considered penalty of detection – Consequence I

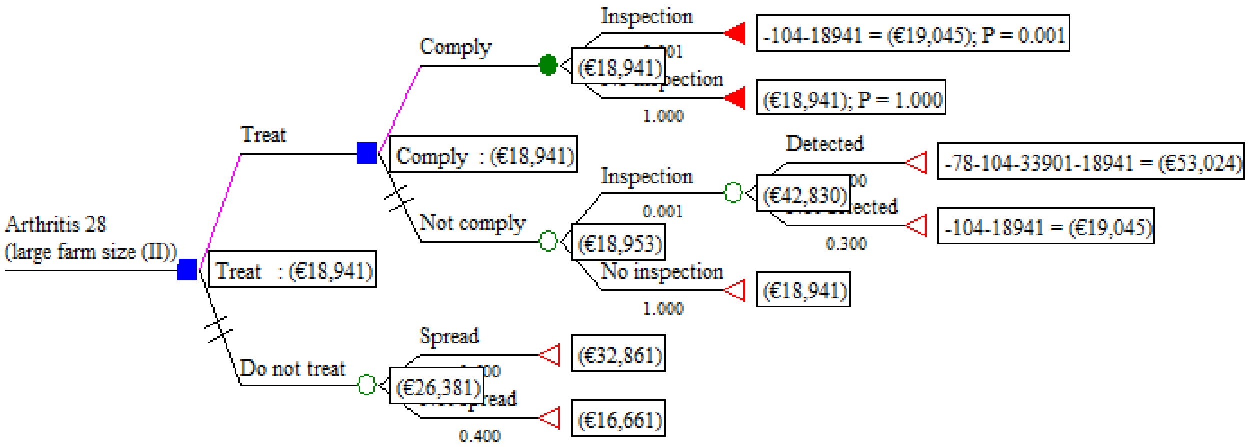

Figure 12: Decision tree of Scenario 4 (A 28), for large farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = 18 941
EMV(not treat) = (1 – P) * 32 861 + P * 16 661 EMV(not treat) = 18 929
18 941 = 32 861 – 32 861p + 16 661p
16 200p = 13 920
P = 0.86

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = 18 941
EMV(not treat) = 0.6 * 32 861 + 0.4 * Z
18 941 = 19 717 + 0.4z
-0.4z = 776
Z = -€1940

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 19 045 + 0.9995 * 18 941
EMV(no compliance) = 0.0005 * X + 0.9995 * 18 941
18 941 = 0.0005x + 18 932
-0.0005x = -9.5
X = €18 941 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 19 045 + 0.9995 * 18 941
EMV(no compliance) = Y * 24 560 + (1 – Y) * 18 941
18 941 = 24 560y + 18 941 – 18 941y
Y = no break-even point regarding probability of inspection

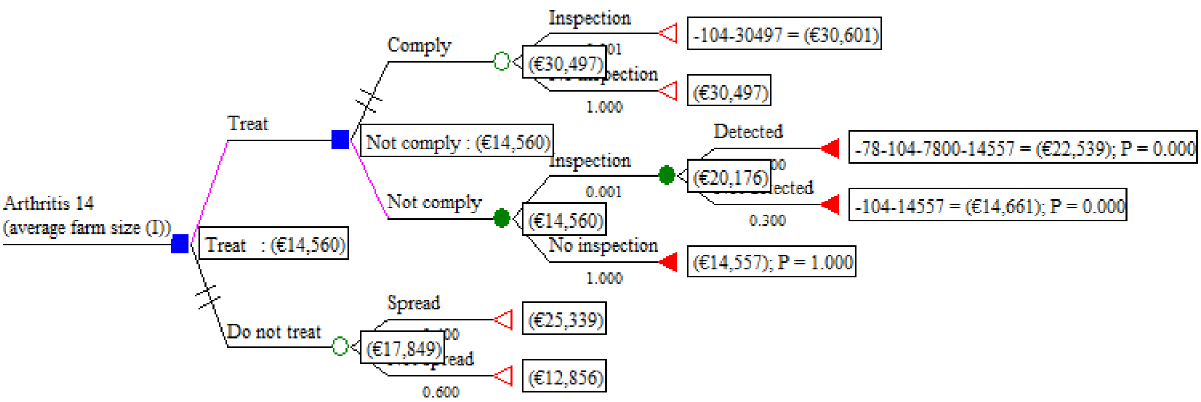

Figure 13: Decision tree of Scenario 5 (A 14), for average farm department and considered penalty of detection – Consequence I

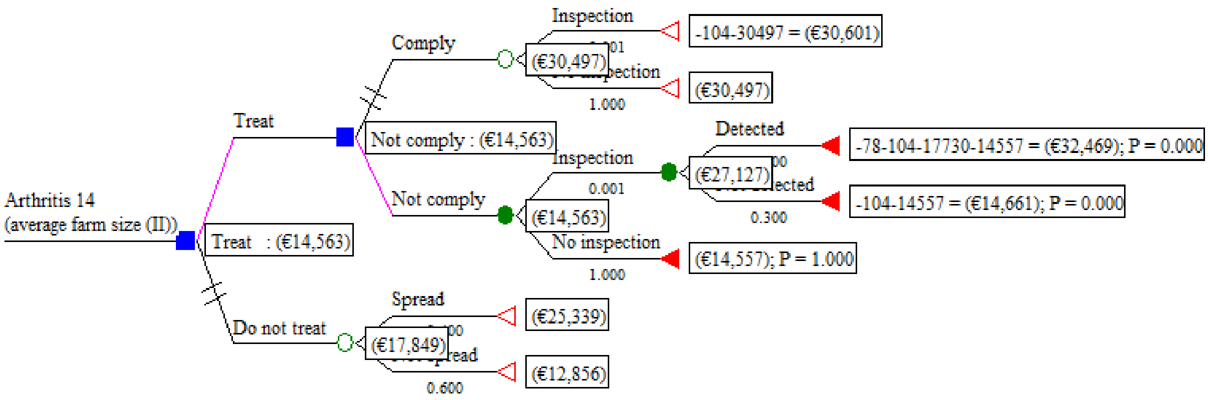

Figure 14: Decision tree of Scenario 5 (A 14), for average farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not treat)
EMV(treat) = 14 563
EMV(not treat) = (1 – P) * 25 339 + P * 12 856 EMV(not treat) = €14 371
14 563 = 25 339 – 25 339p + 12 856p
12 483p = 10776
P = 0.86

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = 14 563
EMV(not treat) = 0.4 * 25 339 + 0.6 * Z
14 563 = 10 136 + 0.6z
-0.6z = -4427
Z = €7378 payoff if disease does not spread

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 30 601 + 0.9995 * 30 497
EMV(no compliance) = 0.0005 * X + 0.9995 * 14 557
30 497 = 0.0005x + 14 550
-0.0005x = -15 947
X = €31 894 557 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 30 601 + 0.9995 * 30 497
EMV(no compliance) = Y * 20 176 + (1 –Y) * 14 557
30 497 = 20 176y + 14 557 – 14 557y
-5619y = -15 940
Y = 2.83, no break-even point regarding probability of inspection

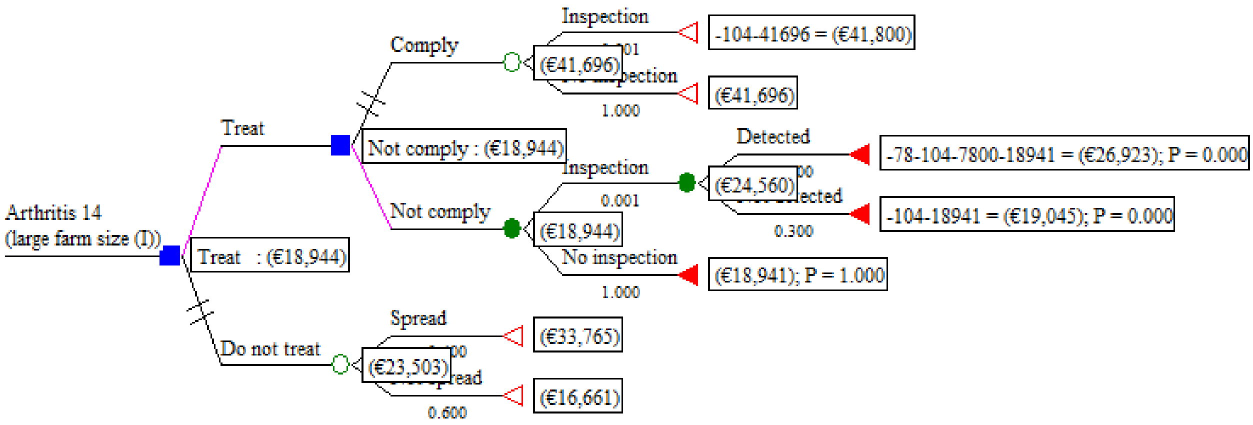

Figure 15: Decision tree of Scenario 5 (A 14), for large farm department and considered penalty of detection – Consequence I

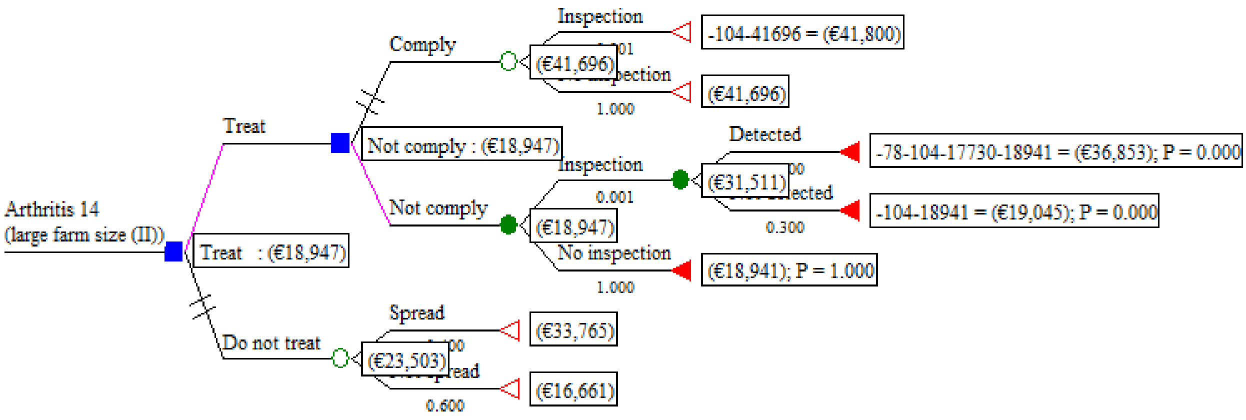

Figure 16: Decision tree of Scenario 5 (A 14), for large farm department and considered penalty of detection – Consequence II

EMV(treat) = EMV(not treat), where payoff(not spread) = Z in EMV(not treat)
EMV(treat) = 18 947
EMV(not treat) = 0.4 * 33 765 + 0.6 * z
18 947 = 0.6z + 13 506
-0.6z = -5441
Z = €9068 payoff if disease does not spread

EMV(treat) = EMV(not treat), where probability(not spread) = P in EMV(not spread)
EMV(treat) = 18 947
EMV(not treat) = (1 – P) * 33 765 + P * 16 661
18 947 = 33765 – 33 765p + 16 661p
17 104p = 14 818
P = 0.87
EMV(not treat) = €18 885

EMV(compliance) = EMV(no compliance), where payoff(penalty) = X in EMV(no compliance)
EMV(compliance) = 0.0005 * 41 800 + 0.9995 * 41 696

EMV(no compliance) = 0.0005 * X + 0.9995 * 18 941
41 696 = 0.0005x + 18 931
-0.0005x = -22 765
X = €45 528 941 penalty

EMV(compliance) = EMV(no compliance), where probability(inspection) = Y in EMV(no compliance)
EMV(compliance) = 0.0005 * 41 800 + 0.9995 * 41 696
EMV(no compliance) = Y * 24 560 + (1 –Y) * 41 696
41 696 = 24 560y + 41 696 – 41 696y
-17 136y = 0
Y = no break-even point regarding probability of inspection

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