Costs and benefits of reduction in antibiotic use at Dutch broiler farms

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Abstract

In intensive animal husbandry the prevention and control of bacterial infections is an important factor of production. Antibiotic use is an effective and relative cheap measure to prevent and control infections, and by that maintain animal health and high production levels. Antibiotic resistance is a drawback of antibiotic use. Increasingly, the frequent use of antibiotics in animal husbandry is linked to the emergence of antibiotic resistance (Bywater et al. 2005). The tendencies of exposure to antibiotics in the Netherlands show an increase in the daily dosage per animal per year on broiler farms, dairy farms and fatting pig farms (MARAN 2008). Because antibiotic use in animal production is high, animal husbandry could be a risk factor for antibiotic resistance.

A policy to reduce the use of antibiotics has to be effective to achieve its goal in reducing the risk of antibiotic resistance, but it should also keep the economic consequences for the broiler farms to an acceptable level. Insight in the costs and benefits of a reduction is therefore very important in this type of policy where economic consequences (e.g. animal health costs, production losses) should be weighed against an increase in human health risk.

The objective of this research is to get insight in the costs and benefits of different scenarios to reduce antibiotic use at Dutch broiler farms. The research focused on economic consequences for the average farmer and for the sector as a whole. The economic costs and benefits of different scenarios and levels of antibiotic reduction are estimated by a partial budgeting model.

The main conclusion of this research is that according to the model a reduction in antibiotic use will result in an increase of the cost of production. The costs related to the increase in mortality and morbidity are in important factor in the increase of the production costs. Additional management another important factor that determines the increase in the cost of production. The cost of additional management measures is high compared to the cost of antibiotics. The financial savings of antibiotic reduction are not high enough to cover the increase in costs. So there is no financial incentive for a farmer to reduce antibiotic use. However there are more incentives that drive a farmer than only finance. Antibiotic resistance is also a problem for farmers. If antibiotic treatment is no longer effective production losses will increase. Antibiotic reduction also fits in the movement of sustainable production. The incentive to give antibiotic treatment is not only to reduce production losses but also because of animal welfare and the treatment of a diseased animal. Reducing antibiotic use can therefore only be accomplished when there are good alternative to prevent and control diseases. Future research on the effect antibiotic reduction has on mortality and morbidity is needed to improve the model. Furthermore research on the development and efficiency of additional management measures and other methods to produce poultry meat without high levels of antibiotics is needed

Table of content

Acknowledgements I
Abstract II
1 General introduction 1
1.1 Background 1
1.2 Objective of the research 3
1.3 Outline of the thesis 4
2 The Broiler sector: an overview 5
3 Bacterial infections and antibiotic use 8
3.1 Bacterial diseases 8
3.2 Trend in antibiotic use 8
3.3 Control and prevention of diseases 9
3.4 Promotion of growth 10
4 Modelling economic effects 12
4.1 Animal health economics 12
4.2 Model introduction 13
4.3 Scenarios of antibiotic reduction 15
4.4 The model 16
5 Results of the model 22
5.1 Economic effects for the average broiler farm 22
5.2 Economic effects on farm level 25
5.3 Economic effects on sector level 27
6 Conclusion and discussion 30
Literature 36

1 General introduction

1.1 Background

The use of antibiotics to treat bacterial infections in humans and animals has been quite successful since they were discovered. An antibiotic is a chemical substance, produced by micro-organisms, which has the capacity to inhibit the growth of and even to destroy bacteria and other micro-organisms (Waksman 1947). Antibiotics are used in human and veterinary medicine to treat or prevent diseases caused by bacteria. When bacteria are exposed to an antibiotic the majority of the bacteria will be killed, but some can survive. The surviving bacteria have a mutation in a gene which allows them to survive, they are resistant to the used type of antibiotic. Antibiotic resistance is one of the drawbacks of the use of antibiotics.

A class of antibiotics called β-lactam antibiotics forms an important component in the armamentarium to treat both Gram-positive and Gram-negative bacterial infections (Poole 2004). The class of β-lactam antibiotics consist of over 50 marketed drugs including; penicillins, cephalosporins, and carbapenems, and forms over 65 percent of the world antibiotic market (Essack 2001; Siu 2002). Unfortunately resistance to β-lactam antibiotics is common in both Gram-native and Gram-positive bacteria (Poole 2004).

Resistance of bacteria against β-lactam antibiotics is caused by the production of β-lactamases, enzymes that hydrolyse the amide bond of the, for β-lactam antibiotics characteristic, four-membered ring and so inactivates the antibiotic (Helfand and Bonomo 2003; Majiduddin et al. 2002). The most frequent detected group of these enzymes in bacteria of animal origin are Extended Spectrum Beta-Lactamases (ESBL's) and AmpC-type beta-lactamases, which both are responsible for antibiotic treatment failure in humans (Dierikx et al. 2010).

Different studies have shown the presence of ESBL's in animals and animal food products in different parts of the world (Hasman et al. 2005; Riaño et al. 2006; Zhao et al. 2009). Bacteria that produce ESBL's or AmpC enzymes are frequently present in the gastro-intestinal tract of animals (Carattoli 2008). The gastro-intestinal tract of animals is seen as important reservoir for ESBL producing bacteria, and a source for bacteria that cause infections in humans to take up genes that encode for the production of these enzymes that cause resistance (Dierikx et al. 2010). It is still unclear if there is a direct exchange of resistance determinants between animal and human bacteria and to what extent the antibiotic use in animal husbandry contributes to the spread of resistance in human isolates (Carattoli 2008). However it is thought that extensive antibiotic use in animal husbandry contributes to the development and spread of antibiotic resistance.

The production of broiler chickens is one of the most intensive types of animal husbandry (Hughes et al. 2008). The broiler industry has achieved its objective of proving a reasonably priced meat product that is also healthy because of its low fat content. This objective is achieved by optimizing several factors including; genetics, farm management, feed diet, and importantly the prevention of diseases (Hughes et al. 2008). The prevention of diseases is partly achieved by the use of antibiotics. The prevention of diseases, due to antibiotic use, increased production but is also thought to increase the chance of antibiotic resistance. Increasingly, the frequent use of antibiotics in animal husbandry is linked to the emergence of antibiotic resistance (Bywater et al. 2005). As a result the European commission banned antibiotics for the purpose of growth promotion in a two-phase process. In the first phase, in 1999, five commonly used antimicrobial growth promoters (AGP's) in feed were banned. In the second phase, January 2006, all the AGP's in feed where banned (Regulation EC No. 1831/2003).

Despite the ban of AGP's the level of antibiotics used in animal production are still very high. The use of antibiotics in Dutch animal husbandry measured in grams per kilo live weight in 2007 was doubled compared to 1999 (MARAN 2008). The increase in antibiotic treatment is thought to be related to the ban of AGP's because the raise of antibiotic treatment started around the time that the fist AGP's were banned. The tendencies of exposure to antibiotics in the Netherlands show an increase in the daily dosage per animal per year on broiler farms, dairy farms and fatting pig farms (MARAN 2008). Because antibiotic use in animal production is still high, animal husbandry could still be a risk factor for antibiotic resistance.

The highest level of resistant bacteria is found on broiler chickens (MARAN 2008). This indicates that the circumstances at broiler farms are optimal for the selection and dissemination of resistant bacteria. In poultry production bacteria like *E. coli* spp. and *Salmonella* spp. are frequently found on broiler farms. These bacteria are part of the natural bacteria culture of chickens as well as other animals. The number of resistant strains of *E. coli* spp. and *Salmonella* spp. but also other bacteria found on chickens is increasing (MARAN 2008).

The Dutch government and various organisations in the field of human health (e.g. Centre for Infectious Disease Control Netherlands (CIb), National Institute for Public Health and the Environment (RIVM), the Central Veterinary Institute (CVI)) agree that the high levels of antibiotics used in animal husbandry are a risk factor for antibiotic resistance and have to be reduced (Coutinho 2010). At broiler farms the level of resistant bacteria is highest, compared to other types of animal husbandry, and the daily dosage of antibiotics per chicken per year is increasing. Therefore a reduction of the use of antibiotics at broilers farms seems logical. In reaction the Dutch government announced that the possibilities to reduce the use of antibiotics will be investigated (Klink and Verburg 2010).

A policy to reduce the use of antibiotics has to be effective to achieve its goal in reducing the risk of antibiotic resistance, but it should also keep the economic consequences for the broiler farms to an acceptable level. Insight in the costs and benefits of a reduction is therefore very important in this type of policy where economic consequences (e.g. animal health costs, production losses) should be weighed against an increase in human health risk. There is a lot of research done and going on about the effects of antibiotic resistant bacteria from animal origin on human health which is mainly focused on microbiology. The economic effects of a reduction of antibiotic use are not studied yet. There appears to be a lack of knowledge when it comes to analyse the economic effects of an antibiotic reduction policy. Without insight in the costs of the reduction for the broiler sector and the social benefits a political decision is hard to make.

1.2 Objective of the research

The objective of this research is to get insight in the costs and benefits of different scenarios to reduce antibiotic use at Dutch broiler farms. The research will focus on economic consequences for the average farmer and for the sector as a whole. The economic costs and benefits of different scenarios for antibiotic reduction will be estimated for the average broiler farmer (90,000 animals per round) and sector as a whole in order to get a better insight in the economic effects of different scenarios on farm and sector level. With the aim of accomplishing the proposed objective the following research questions are formulated.

1. Which strategies of antibiotic reduction are proposed by science?

   The aim of this question is to get insight in the different strategies to reduce antibiotic use. These strategies will be used to construct the different scenarios for which the costs and benefits will be estimated.

2. What are the changes in terms of net costs at a broiler farm and for the sector as a whole when applying different scenarios of reduction of the use of antibiotics?

   The aim of this question is to get better insight in negative and/or positive economic effects of the different scenarios of reduction of antibiotic use. Changes in costs that are directly related to reduction of antibiotic use (e.g. less antibiotic treatment, production losses) will be studied. The costs of possible changes in management to reduce the risk of an outbreak, production losses due to higher mortality and morbidity rates and growth reduction will also be taken in to account. The economic effects will be investigated at farm level and at sector level.

1.3 Outline of the thesis

In chapter 2 an overview of the Dutch broiler sector is given to get a better understanding of the sector that is thesis is about. The purposes of antibiotic use at the broiler farm are described in chapter 3. In chapter 4 the model is explained which will be used to calculate the changes in net cost and benefits for different scenarios of a reduction in antibiotic use. The economic effects of the different scenarios will be modelled by using the partial budgeting method. The results of the model will be presented in chapter 5. Finally the main conclusions of this research will be presented and discussed in chapter 6.

2 The Broiler sector: an overview

This thesis focuses on the economic effects of reduction of antibiotic use at the Dutch broiler farms. To get better insight in how the poultry sector looks like this chapter will give an overview of the sector.

The poultry meat chain in the Netherlands consists of: the grandparent stock, hatcheries, the breeding farms, parent stock farms, hatcheries, the broilers farms, slaughterhouses and producers and retail.

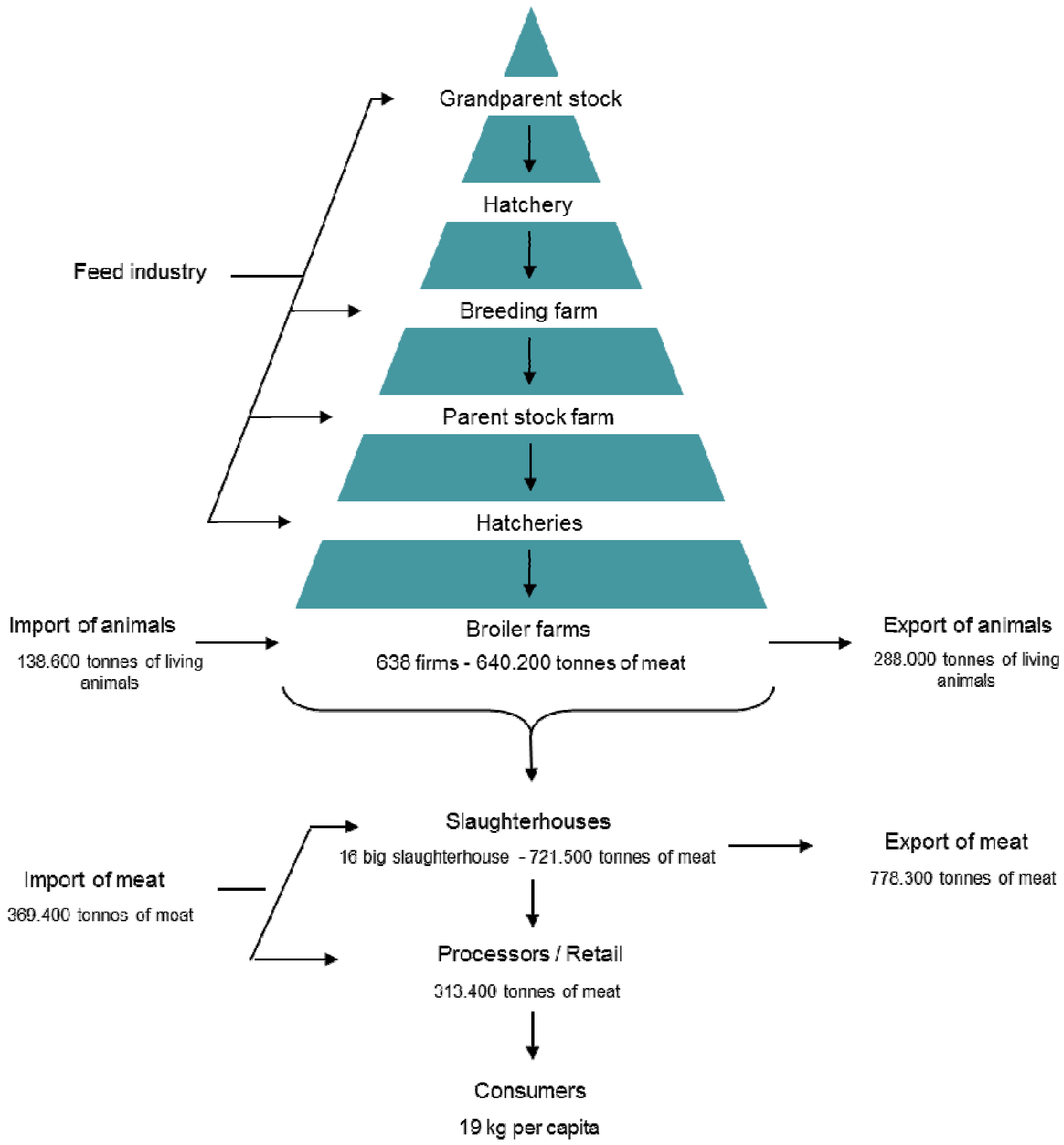

Figure 2.1 The poultry meat chain in The Netherlands (PVE 2010)

The poultry production chain is shaped like a pyramid with respect to the number of firms. The top of the pyramid is formed by the grandparent stock. Worldwide there are three big producers of grandparent chickens: Ross, Cobb and Hubbard. These companies are responsible for the genetics of the majority of the chickens in the chain. From the grandparent stock eggs are supplied to the hatcheries. Once these eggs are hatched the chickens go to the breeding farm. At the breeding farm the production of chickens is scaled up. The chickens supplied by the breeding farm go to the parent stock farm. At the parent stock farm the production of eggs is scaled up. These eggs are hatched at the hatchery who supply the broiler farm with one day old chickens.

At the boiler farm the chickens are raised in six to seven weeks to a weight of 2.1 kilo. The number of broiler farms in the Netherlands has decreased drastically from 2,329 in 1975 to 638 in 2009. However the number of chickens has increased over time (Figure 2.2).

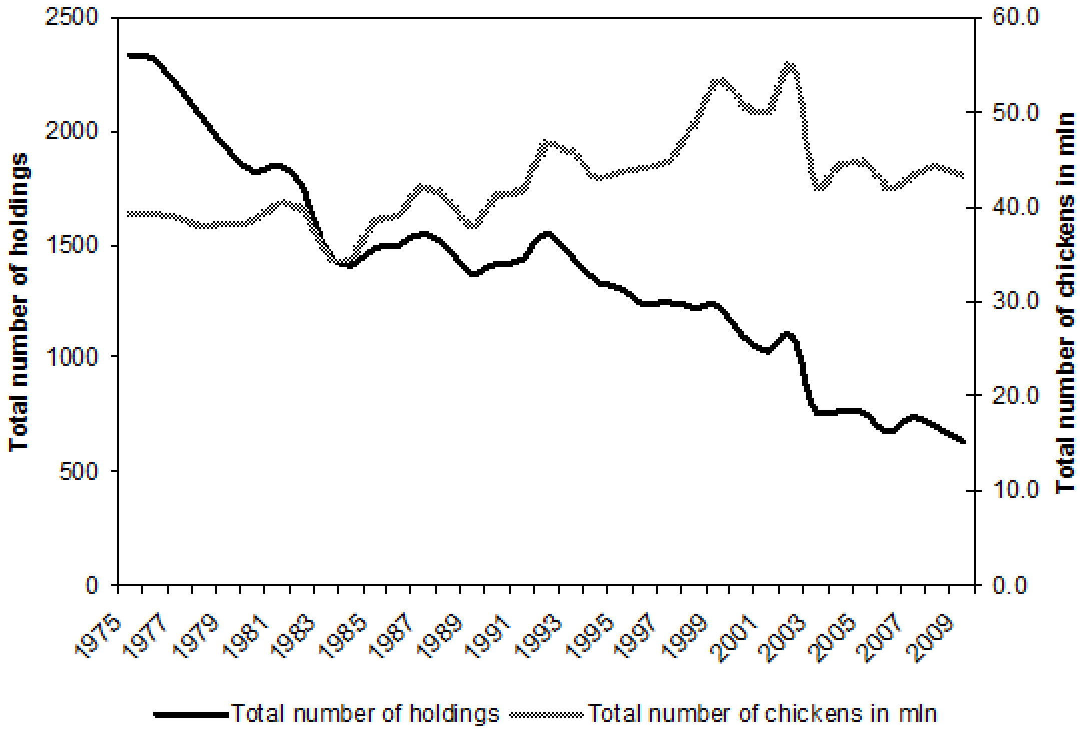

Figure 2.2 Number of broiler farms and total number of chickens in The Netherlands from 1975 till 2009 (LEI 2010)

The number of total chickens reached almost 55 million in 2002 and after that dropped in 2003 to a steady level of around 43 million (Figure 2.2). The decrease between 2002 en 2003 was a result of the Aviaire Influenza (Bird Flu) crises (Plaggenhoef 2007). As a result of the crisis a lot of farms quitted, the share of small farmers (25,000 or less) that quitted was relatively high. The size of the farms has increased and the majority of the farms are now bigger than 50,000 chickens and more than 30 percent of the farms are bigger than 75,000 chickens (Table 2.1).

Table 2.1 Number of broiler farms in The Netherlands from 1970 till 2009 according to number of chickens per farm (LEI 2010)

	less than 10,000	**10,000-25,000**	**25,000-50,000**	**50,000-75,000**	**more than 75,000**	**total number holdings**	**Total number of chickens (in mln)**
1975	822	1,064	350	70	23	2,329	39.3
1980	499	819	366	95	42	1,821	38.6
1985	303	600	403	121	50	1,477	38.4
1990	251	543	386	170	63	1,413	41.1
1995	179	450	403	178	91	1,301	43.8
2000	86	232	379	227	170	1,094	50.9
2005	45	121	243	166	187	762	44.5
2009	38	92	182	125	201	638	43.3

The poultry production has intensified over the years and is now one of the most intensive types of animal husbandry (Hughes et al. 2008). In the whole chain there is a trend of increased scale of production. This has a positive effect on the efficiency of production, but there are also some drawbacks. Production is increased by improving the genetics of the chickens. Combined selection for growth, body composition, feed efficiency and liveability delivers 2 to 3 percent improvement in the efficiency of meat production per year (McKay 2009). A drawback of this process is that if genetic variation decreases the chance that a disease spreads and affects the whole herd increases. High mortality of chickens means an economic loss for broiler farms but also for other stakeholders in the chain. Therefore the prevention of diseases is one of the most important factors of successful poultry production. One of the ways to prevent diseases is the use of antibiotics. The role of antibiotic use in poultry production will be further discussed in the next chapter.

3 Bacterial infections and antibiotic use

In livestock farming antibiotics are used to prevent and control infectious diseases, but sometimes also to promote growth (Schwarz et al. 2001). Both purposes will be discussed in this chapter.

3.1 Bacterial diseases

Good animal health is one of the requirements for profitable animal husbandry. Unhealthy animals cause loss of production due to: higher mortality rates, lower feed efficiency and reduced growth. In the broiler industry mortality is normally about 5% for the entire growth period (Scanes et al. 2004). When mortality is higher this indicates a problem. Other signs that animals have a disease, besides mortality rates, are the following:

- Abnormal feed and water consumption;
- Low growth rate;
- High body temperature, pulse rate and rate of breathing;
- Deviating general sound and activity compared to healthy animals;
- Diarrhea.

The above mentioned signs are general for diseased animals, other more disease specific symptoms can also arise. Diseases can be caused by pathogenic microorganism (bacteria, virus and fungi) or can have genetic and environmental causes (Scanes et al. 2004). Bacteria are single cell microorganisms, fungi are multiple cell microorganisms and viruses are just genetic material (DNA or RNA) with a protein coat and in some cases also a lipid coat (Voeten 2004). Bacteria cause diseases by the extraction of toxic compounds. When these toxins are produced and excreted by living bacteria they are called exotoxins, an example is botulinum. When bacteria die and go in to apoptosis the toxins that are present leak out of the dying cell in to the body, these toxins are called endotoxins (Voeten 2004). These endotoxins are also responsible for fever.

3.2 Trend in antibiotic use

The total sale of antibiotics for veterinary use has increased in the period 1999-2007. The increase in this period is thought to be related to the ban of antimicrobial growth promoters in feed of which the first phase started in 1999 (MARAN 2008). Since 2008 the total sales of antibiotics is decreasing, with 12% in 2008 compared to 2007 and 2% in 2009 compared to 2008 (figure 3.1). The decrease in total sales may be the result of the increased attention for antibiotic resistance and the need to decrease antibiotic use.

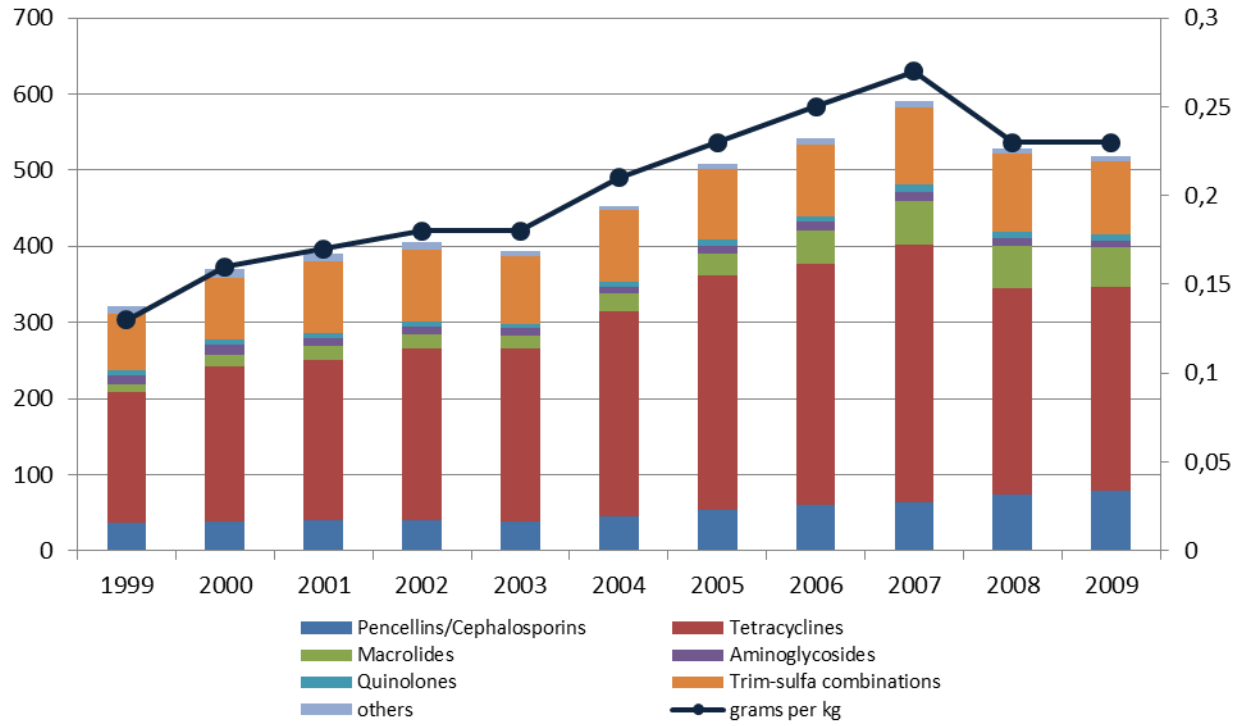

Figure 3.1 Trend total sales therapeutic veterinary antibiotics (MARAN 2008)

The livestock composition has changed in the recent years, but when the antibiotic use is expressed in terms of grams per kilogram living weight (Figure 3.1) the total sales have doubled in 2007 compared to 1999. In 2008 and 2009 the sales in grams per kilogram living weight decreased, but at least half of the reduction in sales in 2008 can be explained by stock piling at the veterinarians (MARAN, 2008).

3.3 Control and prevention of diseases

Control and prevention of bacterial infections is important in intensive animal husbandry. This can be done by either therapeutic, metaphylactic or prophylactic use of antibiotics (Schwarz and Chaslus-Dancla 2001). In therapeutic treatment antibiotics are only given to individual animals that are infected or when an infection is suspected. Metaphylactic treatments are timely mass medication treatments to eliminate or minimize an expected outbreak of an infection. This type of treatment is given when a limited number of animals is identified with an infection and aims to prevent further extension of the infection to the whole herd (Schwarz et al. 2001). Prophylactic treatments are used to prevent a disease from occurring when animals have been or, may have been, exposed to infection sources. These treatments can be used under circumstances like: after vaccinations, transport and mixing of animals (Schwarz and Chaslus-Dancla 2001). The type of treatment, individual or mass, that is chosen to control or prevent the infection depends on the number of animals that is present on the farm, the number of animals that is infected, the risk that the infection spreads and the type of production.

Decreasing costs of antibiotics and the opportunity of mass treatment, via water or feed, have made it possible to treat and prevent diseases and maintain herd health (Gustafson and Bowen 1997). By maintaining the herd health and prevention of diseases the financial investment of the poultry farmers is protected. Early antibiotic treatment and preventative use of antibiotics is more effective than treatment after fully development of the disease in the herd (Gustafson and Bowen 1997). The decision when to start the treatment and which type of treatment to choose is a decision with multiple aspects; cure the diseased animal, to prevent that other animals become infected, maintaining a healthy herd and by that production. The decision when to treat and the type of treatment is made by the farmer and the veterinarian.

The use of antibiotics is only allowed when they are prescribed by a veterinarian. As a part of the antibiotic policy the Royal Dutch Association for Veterinary Medicine (KNMvD) made a list of guidelines (formularium pluimvee) for responsible antibiotic use in the poultry sector. The aim of these guidelines is to create conditions for optimal and effective treatment of bacterial infections and prevent the occurrence and spread of resistant bacteria (KNMvD 2008). The guidelines consist of a list of antibiotics that are ranked according to effectiveness and possible attribution to antibiotic resistance. Based on these criteria a treatment plan with; first, second and third option antibiotics, is suggested to treat the most common bacterial infections. The veterinarian uses the guidelines as proposed by the KNMvD to formulate a treatment plan for an individual farm (KNMvD 2008).

3.4 Promotion of growth

Besides the health effect, antibiotics have also a beneficial effect on the growth of animals. For example an increased growth response when streptomycin, an antibiotic, was added to the diet of chickens was observed by Moore *et al*. (1946) (Moore et al. 1946). Other studies showed also a positive effect of antibiotics on the growth of chickens (Gustafson and Bowen 1997). An increase in body weight in chickens fed with antibiotics compared to chickens fed without antibiotics was shown by Libby and Schaible (1955) (Libby and Schaible 1955). The increase in growth is associated with the better health of the gut. The mechanism of action was thought to be that the antibiotics reduced the presence of gram-positive microorganisms which interfere with the absorption of nutrition (Essyen and Somer, 1962). Today several mechanisms of action are attributed to growth promotion due to antibiotics but full understanding has not been achieved (Graham et al. 2007). Nevertheless the use of antibiotics, already in small levels added to the feed, increases the growth and feed efficiency in poultry and also show to be effective in the prevention of diseases (Gustafson and Bowen 1997).

The use of antibiotics as additive in feed, for the purpose of disease prevention and growth promotion, is criticized because of the possible attribution to the selection of antibiotic resistant bacteria and the spread of resistance genes (Schwarz et al. 2001). Because of this, the number of drugs available for the purpose of growth promotion was limited to four and antimicrobial growth promoters in feed where banned in 1999 (Schwarz and Chaslus-Dancla 2001). Data suggest that the ban of antimicrobial growth promoters in feed (first phase in 1999) increased infections and therefore increased therapeutic antibiotic treatment (Casewell et al. 2003). If the ban of antimicrobial growth promoters in feeds already increased infections, a reduction of therapeutic antibiotic use could also result in an increase of infections which could result in production losses. It has been shown that competitive poultry production is possible after the ban of antimicrobial growth promoters by improving farm hygiene and production conditions (Wierup 2001). Whether competitive poultry production is also possible when therapeutic treatment is reduced will be further investigated in this research.

4 Modelling economic effects

4.1 Animal health economics

Prevention and control of diseases is an important factor in animal husbandry. Diseases have a negative effect on the process of converting resources into outputs. Most diseases can be controlled with animal health management, including the use of vaccines and antibiotics. The use of antibiotics has increased production and efficiency, but there are also drawbacks. Resistance is becoming a growing problem. When antibiotic treatment is no longer effective bacterial infections will negatively affect production again. Antibiotic reduction could be a measure to stop the increasing number of bacteria that become resistant to antibiotics.

Animal health economics has played an important role in analysing the economic effect of measures to control diseases. The framework to analyse disease in livestock production by McInerney (1996) (figure 4.1) is used to analyse the economic effect of animal diseases, but could also be used to analyse the economic effect of antibiotic reduction.

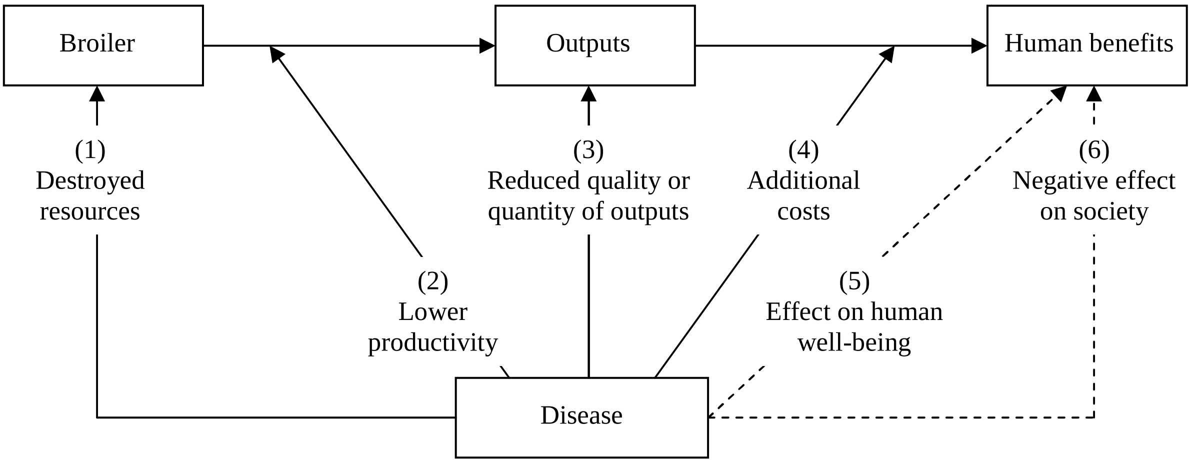

Figure 4.1 Diseases in the livestock production system (McInerney 1996)

Animal diseases in a given production system reduce the efficiency of which recourses are converted in outputs. The effect of a disease can be direct or indirect. Direct and indirect losses may occur as follows:

Direct effects:

(1) The disease has a direct effect on resources in destroying them e.g. mortality;

(2) The disease directly lowers the productivity of the resources e.g. morbidity and reduced feed conversion;

(3) The disease has a direct effect on the quality or quantity of outputs e.g. lower body weight and less uniformity;

Indirect effects:

(4) Losses due to additional costs to reduce or avoid incidence of diseases or compensate the negative effects on production e.g. measures to control and prevent bacterial infections (e.g. antibiotics), extra feed to compensate reduced growth due to morbidity;

(5) Effecting human well-being e.g. ESBL's;

(6) An array of more diffuse negative economic effects which reduce the value a society gains form livestock production, e.g. constrains in trade, a feeling of reduced food safety by consumers.

The economic effect of a reduction in antibiotic use will be calculated using a model that will be explained in the next section. In the model the cost of the direct effects (1) and (2) and indirect effect (4), are calculated.

4.2 Model introduction

The model estimates the costs and benefits of different levels of antibiotic reduction at farm level for an average farm and for the whole broiler sector (i.e. the Dutch broiler farmers). A reduction in antibiotic use will have an effect on the costs and benefits of a livestock production system. Reducing antibiotic use has an effect on the chance and severity of possible disease outbreaks. Because of this relation the framework of McInerney (figure 4.1) is used to identify the economic effects (i.e. costs and benefits) of a reduction in antibiotic use. The costs and benefits of the direct and indirect economic effects are estimated using the partial budgeting technique. The net costs will be calculated for the different levels of antibiotic reduction.

Partial budgeting is a decision-making framework used to quantify economic consequences of changes in farm procedures. All aspects (costs and benefits) that are unchanged by the decision can be safely ignored. The general format of a partial budgeting framework is made up of four categories: additional returns, reduced costs, reduced returns and additional costs (Dijkhuizen and Morris 1997). The aspects that change due to the different levels of antibiotic reduction will be calculated and result in the net costs of different levels of antibiotic reduction. Partial budgeting is useful to analyse changes in business as a result of a change in policy (Dijkhuizen and Morris 1997). The model will quantify the economic consequences of a reduction in antibiotic use at farm level and for the sector as a whole. The time horizon of the model is one year. In the model the costs and benefits are calculated for three scenarios of antibiotic reduction i.e. 20%, 50% and 100% reduction. The model calculates first the costs and benefits for the current situation which will then be used as the baseline.

Reducing antibiotic use will change the costs and benefits. The effect of a reduction in antibiotic use for production can differ. Figure 4.2 shows two possible effects of a reduction in antibiotic use. The upper part of the figure shows the situation in which the frequency or severity of bacterial infections will increase as a result of antibiotic reduction. The lower part shows the situation in which the consequences for the health status of the animals is minimal. In the model it is assumed that a reduction in antibiotic use will change the health status of the animals (the upper part). In the case of an increase in the frequency or severity of infection a farmer will possibly try to prevent and control bacterial infection with investment in additional management measures, for example a new drinking water system or probiotics.

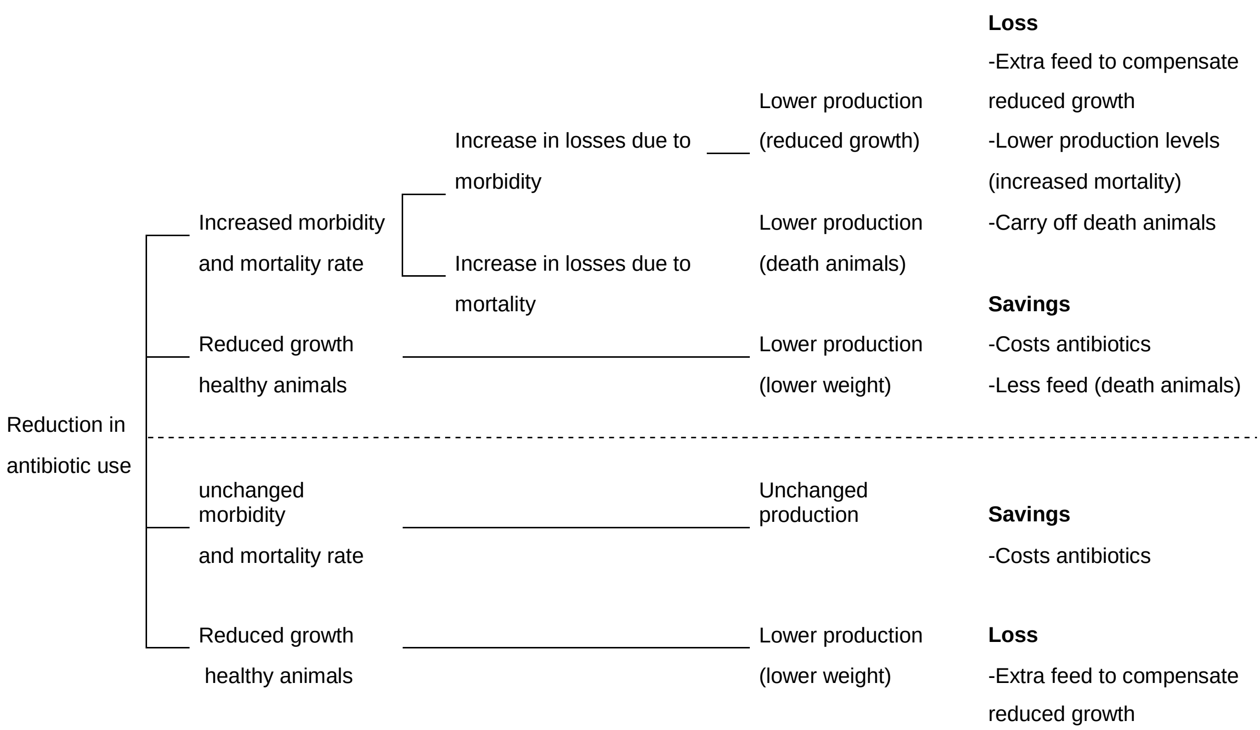

Figure 4.3 Possible effects of a reduction in antibiotic use for production

Reduced production levels and as a consequence lower farm income, as a result of a reduction in antibiotic use, can possibly be compensated by changes in technical management. Production levels can be reduced as a result of reduced growth of diseased animals but also healthy animals. With technical management like for example; probiotics or extra vitamins, production losses can be compensated. The costs and benefits of changes in additional management will be taken in to account in the model.

4.3 Scenarios of antibiotic reduction

In the model the net costs for different levels of antibiotic reduction (20%, 50% and 100%) are calculated. The model calculates the costs and benefits for the current situation and the different levels of antibiotic reduction. The net costs are calculated for six scenarios (Table. 4.3). In the three A scenarios it is assumed that the risk of health problems increases when the antibiotic use is reduced. Furthermore it is assumed that the farmer will not change his management, no measures are taken by the farmer to prevent or control infections. In the B scenarios it is assumed that the farmer will change his animal health management by investing in systems to prevent infections (e.g. a floor heating and cooling system). Furthermore it is assumed that the farmer will change his technical management to compensate for production losses. The number and types of measures that the farmer will invest in increase as the level of antibiotic reduction decreases. This is based on the assumption that the higher the level of antibiotic reduction, the higher the avoidable disease cost and as a result it is assumed that the farm will invest in more measures as the level of antibiotic reduction increases. As a result of the changes in management it is assumed that for all the three B scenarios the risk will be at the current level.

Table 4.3 Scenarios antibiotic reduction

	Scenario A 20%	**Scenario A 50%**	**Scenario A 100%**	**Scenario B 20%**	**Scenario B 50%**	**Scenario B 100%**
Health problems						
Risk digestion problems	Increased	Increased	Increased	Current	Current	Current
Risk respiratory problems	Increased	Increased	Increased	Current	Current	Current
Risk locomotion problems	Increased	Increased	Increased	Current	Current	Current
Risk first-week problems	Increased	Increased	Increased	Current	Current	Current
Health costs						
Reduction costs antibiotic treatment	20%	50 %	100 %	20%	50 %	100 %
Animal health management						
Investment in new drinkingwater system	-	-	-	-	X	X
Investment new ventilation system	-	-	-	-	-	X
Investment new floor heating and cooling	-	-	-	-	X	X
Technical management						
Costs increased vitamin intake	-	-	-	X	X	X
Costs probiotic use	-	-	-	X	X	X

4.4 The model

The partial budgeting model calculates the costs and benefits of the different scenarios of antibiotic reduction. The calculations that are made by the model will be described in this section. The model consists of three main parts; (1) losses due to mortality and morbidity for possible bacterial infections, (2) costs of changes in management to reduce the risk of a bacterial infection and (3) costs of antibiotic treatment, to calculate the net costs of the different scenarios of antibiotic reduction.

The inputs that are used in the model are given in table 4.4a, 4.4b and 4.4c. Some inputs are a result of a calculation, the calculations are given in the model description below. The inputs of these calculations are given in the table.

Table 4.4a Mortality rates for the current situation and the levels of antibiotic reduction

		Current	20% antibiotic reduction	50% antibiotic reduction	100% antibiotic reduction
$MRT_{digestion}$	*Mortality rate of digestion problems*	0.0100	0.0110	0.0130	0.0150
$MRT_{respiratory}$	*Mortality rate of respiratory problems*	0.0050	0.0055	0.0065	0.0075
$MRT_{locomotion}$	*Mortality rate of locomotion problems*	0.0050	0.0055	0.0065	0.0075
$MRT_{first-week}$	*Mortality rate of first-week problems*	(1)0.0150	0.0165	0.0195	0.0225

(1) (Yassin et al. 2009)

Table 4.4b Morbidity rates for the current situation and the levels of antibiotic reduction

		Current	20% antibiotic reduction	50% antibiotic reduction	100% antibiotic reduction
$MBR_{digestion}$	*Morbidity rate of digestion problems*	0.20	0.24	0.30	0.40
$MBR_{respiratory}$	*Morbidity rate of respiratory problems*	0.10	0.12	0.15	0.20
$MBR_{locomotion}$	*Morbidity rate of locomotion problems*	(2)0.30	0.36	0.45	0.60
$MBR_{first-week}$	*Morbidity rate of first-week problems*	0.10	0.12	0.15	0.20

(2) (Sanotra et al. 2001)

Table 4.4c Model inputs

Input	Destiption	value	unit	source
N_{rounds}	*Number of rounds per year*	7		(LEI 2011)
N_{total}	*Total number of chickens per farm*	540,000	# animals/yr/farm	(LEI 2011)
TVM_0	*Total value at day 0*	0.80	€	calculations
TVM_7	*Total value at day 7*	0.87	€	calculations
TVM_{14}	*Total value at day 14*	0.98	€	calculations
TVM_{21}	*Total value at day 21*	1.13	€	calculations
TVM_{28}	*Total value at day 28*	1.33	€	calculations
TVM_{35}	*Total value at day 35*	1.55	€	calculations
TVM_{42}	*Total value at day 42*	1.85	€	calculations
W	*Weight of a chicken*	2.150	kg	(KWIN 2010)
ΔFCR	*Increase in food rate conversion*	0.050		assumption
FCR	*Food rate conversion*	0.06	kg/dag	(KWIN 2010)
ΔFCRA	*decrease in food rate conversion due to antibiotic reduction*	0.016		assumption

%W	*Relative reduction in weight*	0.05		assumption
P_f	*Price of feed (weighted average)*	0.235	€/kg	(KWIN 2010)
P_m	*Price of meat*	0.86	€/kg	(Agd.nl 2011)
$P_{vitamin}$	*Price of vitamins per chicken per treatment*	0.01	€/animal	assumption
$P_{probiotic}$	*Price of probiotics per chicken per treatment*	0.01	€/animal	assumption
CD	*Destruction costs*	0.02	€/animal	(Rendac 2011)
C_t	*Cost of antibiotic treatment per chicken per year*	0.02	€/animal	(LEI 2009)
C_f	*Cost of the increased FCR*	0.00	€/animal	calculation
C_{rw}	*Cost of reduced weight*	0.09	€/animal	calculation
$P_{chicken}$	*Purchase price chicken*	0.265	€	(KWIN 2010)
F_{total}	*Feed intake per animal in kg*	3.68	#kg	(KWIN 2010)
LS	*Lifespan of investment*	12.50	years	(KWIN 2010)
RC_{drink}	*Replacement cost drinking system*	11.00	€/m²	(KWIN 2010)
$RC_{ventilation}$	*Replacement cost ventilation system*	25.00	€/m²	(KWIN 2010)
$RC_{cooling}$	*Investment in floor heating and cooling system*	20.00	€/m²	(KWIN 2010)
L_i	*Effect on labour cost*	0.00		assumption
λ_i	*Scale factor of investment i*	1.00		assumption

Calculation of losses due to mortality

The usual on-farm mortality in broiler flocks is around 5% for the entire growth period (Scanes et al., 2004). An outbreak of a bacterial infection might increase the number of death animals. The number of death animals during an outbreak is considered in the model as losses due to mortality of the specific diseases. During the growth period a chicken represents a value which is used in the model to quantify the financial loss of mortality. The value of a chicken consists of the purchase price, feed costs, overhead costs (management, energy, housing, medication) and the profit margin. Feed and overhead costs vary in time and increase during the growth period. Because of this the value of a chicken is calculated at different moments in time. The loss due to mortality (LMT_i), for a bacterial disease *i,* is calculated by multiplying the mortality rate (MRT_i) by the number of chickens at the farm *i* per year (N_i), multiplied by the total value at the time of mortality (TVM_i) and the destruction costs (CD) (Eq.1).

$$LMT_i = MRT_i \times N_i \times (TVM_i + CD) \quad (1)$$

The total number of chickens at the farm *i* (N_i) is calculated by multiplying the capacity per round by the an assumed number of 7 round per year.

The total value at the time of mortality (TVM_i) consists of: the purchase price, the cumulative feed costs, overhead and a profit margin. The feed costs increase over time as more feed is consumed (4.5a). The total value at the time of mortality is calculated for each week (Table 4.5b).

Table 4.5a Feed consumption over time (Williams 1999).

Bird age (weeks)	**1**	**2**	**3**	**4**	**5**	**6**
Feed consumed %	3.70%	12.80%	27.30%	46.40%	69.40%	100.00%

Table 4.5b Total value different moments in time.

Bird age (weeks)	**1**	**2**	**3**	**4**	**5**	**6**
Purchase price (€)	0.27	0.27	0.27	0.27	0.27	0.27
Overhead (€)	0.03	0.06	0.09	0.12	0.15	0.18
Profit margin (€)	0.54	0.54	0.54	0.54	0.54	0.54
cumulative feed costs (€)	0.03	0.11	0.24	0.40	0.60	0.86
Total (€)	0.87	0.98	1.14	1.33	1.56	1.85

In the model the losses due to mortality are separately calculated for the four categories of infections (first-week, locomotion, digestion and respiratory problems) that are in the model. A reduction in antibiotic use is assumed to increase the probability of a disease outbreak, the number of infected animals and by that an increased mortality rate. The model calculates the losses due to mortality for the current situation and for the scenarios of a 20%, 50% and 100% reduction in antibiotic use.

Calculation of losses due to morbidity

Morbidity is assumed to have a negative effect on the growth of animals. In the model it is assumed that as a result of the infection the Feed Conversion Ratio (FCR) increases. The Feed Conversion Ratio is a measure for the efficiency an animal converts feed mass into body mass, and is calculated by dividing the body weight by the feed in kg. If due to the infection the growth (weight gain) decreases, as a result the FCR increases. The cost of the increased FCR (C_f) is calculated by multiplying the weight of chicken (W) by the increase in FCR (ΔFCR), multiplied by the price of feed (P_f) (Eq. 2).

$$C_f = W \times \Delta FCR \times P_f \quad (2)$$

In the model it is assumed that as a result of the infection and the increased FCR the chicken will have a lower body weight at the end of the growth period (42 days). The loss of this lower weight (C_{rw}) is calculated by multiplying the relative reduction in weight $(\%W)$ by the normal weight of a chicken, (W) multiplied by the price of meat (P_m) (Eq. 3).

$$C_{rw} = \%W \times W \times P_m \quad (3)$$

To calculate the total loss due to morbidity (LMB_i) equations 2 and 3 are combined and multiplied by the number of chickens that suffer from the disease, which is calculated by multiplying the morbidity rate (MBR_i) by the number of infected animals. The number of infected animals is calculated by multiplying the total number of animals at the farm (N_i) by one minus the mortality rate (MRT_i).

$$LMB_i = MBR_i \times (N_i \times (1 - MTR_i)) \times (C_f + C_{rw}) \quad (4)$$

In the model it is assumed that the morbidity rate increases when the antibiotic use is reduced. The magnitude of the increase is unknown at the moment. For the three scenarios it is assumed the morbidity rate is increased with the same percentage as the antibiotic reduction, so of the scenario of a 20% reduction in antibiotic use it is assumed that the morbidity rates increase by 20%.

Calculation of losses due to reduced growth healthy animals

Several studies showed the positive effect that antibiotics have on the growth of chickens (Moore et al., 1946; Libby and Schaible,1955). The reduction in antibiotics use can result in a decreased growth rate of the healthy animals. In the model it is assumed that the chickens will get an extra amount of feed to compensate for the reduced growth. The costs of this effect (CRG) are calculated by multiplying the weight of chicken (W) by the decrease in FCR $(\Delta FCRA)$, multiplied by the price of feed (P_f), multiplied by the total number of animals corrected for mortality (Eq.5). The total number of animals is corrected for mortality by multiplying total number of animals at the farm (N_i) by one minus the mortality rate (MRT_i).

$$CRG = W \times \Delta FCRA \times P_f \times (N_i (1 - MRT_i)) \quad (5)$$

Avoidable disease costs

The total costs of diseases in the model consists of losses due to mortality and morbidity. In the model these costs are named avoidable disease costs. To calculate the avoidable costs of a category of infections the sum of losses due to mortality and morbidity are multiplied by the chance that an infection will occur. The avoidable disease costs are calculated separately for the four categories of infections and the different scenarios of antibiotic reduction.

Cost of changes in management

In the model it is assumed that due to the reduction in antibiotic use the chance of an outbreak and the number of chickens that will be infected given a disease outbreak will increase (i.e. the severity of the disease increases). To reduce the chance of an outbreak the farmer can change his animal health management. Animal health management, as meant in the model, are measures that prevent or control infections. Antibiotics are used to prevent and control infections but if antibiotic use has to be reduced it is assumed that the farmer invests in other measures to prevent and control diseases for example; improvement of the shed, investment in a climate system or extra cleaning during and before a production round. In general the cost of an investment $i\,(INV_i)$ is calculated by multiplying the replacement cost (RC_i) by its unit (e.g. m²), and divide this total cost of replacement by its lifespan (LS_i) (Eq. 6). The size of a farm can affect the costs of an investment, for some investments economies of scale will apply. If this is the case this will be taken in to account in scale factor λ_i. Investment in new equipment can have an effect on the hours a farmer works on the farm. This effect on labour can be positive: more hours of e.g. monitoring or negative: a decrease of the labour due to computerization of systems. The effect on labour cost is represented in (L_i) .

$$INV_i = \frac{RC_i \times unit}{LS_i} - \lambda_i + L_i \qquad (6)$$

The cost of the following investments in animal health management measures are part of the model.

-Investment in new drinking water system;
-Investment new ventilation system;
-Investment new floor heating and cooling system.

The replacement cost (RC_i) for the investments that are in the model are based on price per square meter and an assumed lifespan of 12,5 years. The number of square meters of a farm (S_i) is calculated by dividing the shed capacity (number of chickens per round) by an assumed occupancy of 24 animals per square meter. Investments in animal health management aim at preventing and controlling infections. The positive effects (i.e. reduced chance of an outbreak or reduced morbidity and/or mortality) of the investments in animal health management are not directly calculated for an individual investment. It is assumed that the total set of investments will reduce: the chance of an outbreak, morbidity rate and/or mortality rate.

Technical management measures, as meant in the model, are measures to compensate production losses due to morbidity (i.e. reduced growth). In the model it is assumed that the farmers are risk averse and that they will try to compensate production losses by changing their technical management for example; probiotics, extra vitamins or higher quality feed. It is assumed that the level of improvement in technical management depends on the level of antibiotic reduction (i.e. increases when antibiotics are reduced). The costs of a technical measure i (CTM_i) is calculated by multiplying the price (P_i) per unit (e.g. animal, kg or treatments) by the number of units used per year (Eq. 7).

$$CTM_i = P_i \times unit \quad (7)$$

The level of animal health management and technical management vary among the different levels of antibiotic reduction. It is assumed that when the level antibiotic reduction is higher more management changes will be applied.

Savings reduced antibiotic use

When antibiotic use is reduced the cost of antibiotics and other costs related to antibiotic treatment are reduced. The cost reduction (C_a) is calculated by multiplying the relative reduction in antibiotic use $(\%AR)$ by the cost of treating one chicken per year (C_t), multiplied by the number of chickens (N_i) (Eq 5).

$$C_a = \%AR \times C_t \times N_i \quad (8)$$

5 Results of the model

The model as described in chapter 4 is used to calculate the cost and benefits of antibiotic reduction in poultry farming. The model quantifies the economic consequences of a reduction in antibiotic use at farm level and for the sector as a whole for three scenarios 20%, 50% and 100% antibiotic reduction. The results will be discussed in this chapter.

5.1 Economic effects for the average broiler farm

In the model the costs and benefits for the three levels of antibiotic reduction are calculated for the average farm. The average farm is defined as a farm with a shed capacity of 90,000 chickens per round which correspond to a floor space of 3,750 m². In the model it is assumed that there are 7 production rounds per year, so the total number of animals on the farm is 540,000 per year.

Disease costs

In the model the disease costs represents the losses due to mortality and morbidity of chickens. The disease cost is calculated separately for the four categories of diseases (fist-week, locomotion, respiratory and digestion problems). Table 5.1 shows the calculated values for the current situation and the disease cost when the level of antibiotics is reduced.

Table 5.1 Calculated values for disease costs for the current situation and the three levels of antibiotic reduction

	Currents costs	Costs 20% antibiotic reduction	Costs 50% antibiotic reduction	Costs 100% antibiotic reduction
Digestion problems (€)	5,925	6,914	8,488	10,856
Respiratory problems (€)	1,672	1,940	2,373	3,008
Locomotion problems (€)	11,632	13,698	16,918	21,945
First-week problems (€)	9,717	11,081	13,404	16,514
Total (€)	28,945	33,633	41,183	52,323
Avoidable disease costs (€)		4,688	12,238	23,378
Δ% compared to current		16%	42%	81%

The model estimates the total disease cost for the current situation for an average broiler farm (90,000 chickens per round) at 28,945 euro. Table 5.1 also shows the disease costs when the level of antibiotic use is reduced. The model estimates that the total avoidable disease cost will be 4,688 euro when the antibiotic use is reduced with 20%. When antibiotic use is reduced with 50% the total avoidable disease cost be 12,238 euro. When the antibiotic use is reduced with 100% the model estimates that the total avoidable disease cost will be 23,378 euro. In the last row of table 5.1 the total avoidable disease cost is given as a percentage of the disease cost in the current situation. When the antibiotic use is reduced with 20% the model estimates that the disease cost will increase with 16% and a reduction of 50 and 100% will result in an increase of the cost with 42% and 81% respectively.

The main part of the increase in disease costs is explained by the increased morbidity rate. The losses due to morbidity are 65 to70% of the total avoidable disease costs. The sharp rise of the disease costs as the antibiotic use is reduced is explained by the assumption that the morbidity rate increases with the same percentage as the antibiotic use is reduced, so in the scenario of 50% antibiotic reduction it is assumed that the morbidity rate is 1.5 times the current rate.

Additional costs of changes in management

In scenario B it is assumed that the farmer will invest in measures to prevent or control disease when the use of antibiotics is reduced. There are two types of measures in the model; changes in health management and changes in technical management. The type of measures that are in the scenarios differ between the level of antibiotic reduction. In the model an assumption is made which measures will be applied for each of the levels of antibiotic reduction. In practice a farmer will make the decision which measures to apply based on a cost benefit analysis. The benefits of addition management measures are unknown, and future research should focus on that. Because the effect of the additional measures on mortality and morbidity is unknown for the three levels of antibiotic reduction sets of additional measures are assumed. The annual cost for the different measures and the types of measures that are in the scenarios are given in table 5.2. For the calculation of the annual cost a lifespan of 12.5 year is assumed. Because the timeline of the model is one year the annual investment is not corrected for inflation. The total investment of additional animal health measures are given in table 5.3.

Table 5.2 Calculated annual cost for additional animal health and technical measures

	Scenario B 20% AB reduction	**Scenario B 50% AB reduction**	**Scenario B 100% AB reduction**
Animal health management (INV)			
Investment in new drinkingwater system	0	3,300	3,300
investment new ventilation system	0	0	7,500
Investment new floor heating and cooling system	6,000	6,000	6,000
Subtotal (€)	6,000	9,300	16,800
Technical management (CTM)			
Costs increased vitamin intake	0	0	5,400
Costs probiotic use	0	5,400	5,400
Subtotal (€)	0	5,400	10,800
Total (€)	**6,000**	**14,700**	**27,600**

In the model it is assumed that when the antibiotic use is reduced with 20% a farmer will only invest in a new floor heating cooling system. The annual cost of this investment is 6,000 euro, the total investment is 75,000 euro. When the level of antibiotics is reduced with 50% it is assumed that the farmer will invest in a new dinkingwater system, a new floor and cooling system and probiotics. The total annual cost of all these measures equals 14,700 euro. The total investment in animal health measures for the scenario of 50% reduction is 116,250 euro. When antibiotic use is reduced with

100% the disease cost are, according to the model increased with 81% and therefore it is assumed that the farmer will invest in all the measures that are in the model. The annual cost of this set of measures is 27,600 euro. The total investment in additional animal health measures for the scenario of 100% reduction is 210,000 euro.

Table 5.3 Calculated total investment for additional animal health measures

	Scenario B reduction AB 20%	Scenario B reduction AB 50%	Scenario B reduction AB 100%
Investment in new drinkingwater system	0	41,250	41,250
Investment new ventilation system	0	0	93,750
Investment new floor heating and cooling system	75,000	75,000	75,000
Total (€)	75,000	116,250	210,000

The calculated total investment in additional animal health measures is high. In the period between 2001 and 2009 the average investment in buildings, equipment and systems was 52,000 euro per year (Binternet LEI, 2011). In the years 2007, 2008 and 2009 the investments were high above the 8 years average. In these 3 years the average investment in buildings, equipment and systems per farm was 102,000 euro (Binternet LEI, 2011). In relation to these figures a reduction in antibiotic use would result in a serious increase of investment. In the calculation of the investments in animal health measures it is assumed that as a result of a reduction in antibiotic use the farmer needs to renew the total system. So depending on the technical status of the farm the total investment could be lower.

Savings reduced antibiotic use

Reducing antibiotic use results in reduced cost of antibiotic treatment (table 5.4). The annual cost reduction when the level of antibiotic use is reduced with 20% is 2,006 euro. A reduction of 50% will result in an reduction of treatment cost by 5,014 euro, and 10,029 euro when the antibiotic use is reduced with 100%. The financial savings of a reduction in antibiotic use are low compared to the cost of additional management or the increase in avoidable disease costs, showing that antibiotics are a cheap solution to animal health problems. Costs for visits of veterinarian are not taken in to account because it is unknown if the number of visits by a veterinarian will change as a result of antibiotic reduction.

Table 5.4 Calculated savings reduced antibiotic use

	20% AB reduction	50% AB reduction	100% AB reduction
Savings reduced antibiotic use (€)	2,006	5,014	10,029

Losses due to reduced growth of healthy animals

Preventative antibiotic use has a positive effect on growth of healthy animals. When antibiotic use is reduced this effect is lost. It is assumed that as a result of antibiotic reduction the food conversion rate will decrease. Furthermore it is assumed that the farmers will compensate the reduced growth by given extra feed. The decrease in the feed conversion rate is used to calculate the extra amount of feed. The costs of these extra amounts of feed are given in table 5.5.

Table 5.5 Calculated loss due to reduced growth healthy animals

	20% AB reduction	50% AB reduction	100% AB reduction
Loss due to reduced growth healthy animals (€)	839	2,083	4,136

The loss due to reduced growth when antibiotic use is reduced by 100% is 4,236 euro. In the model it was assumed that the losses for the scenarios of 20% and 50% antibiotic reduction are 20% and 50% of the loss when antibiotic use is reduced by 100%.

5.2 Economic effects on farm level

All the costs and benefits that are in the model are separately discussed in the previous section. In this section the results will be discussed on farm level and will be related to production costs.

Cost and benefits of a reduction in antibiotic use

In table 5.6 an overview is given of the calculated costs and benefits of a reduction in antibiotic use. The net costs of the scenarios are calculated by deducting the costs; avoidable disease costs, costs of additional management measures and the loss due to the reduced growth of healthy animals by the savings of antibiotic use. The net costs for all the scenarios are negative which indicate that reducing antibiotic use increases the costs of production.

Table 5.6 Calculated annual costs and benefits of a reduction in antibiotic use

	Avoidable disease costs	Savings antibiotic use	Additional management	Loss growth	Net costs
Current	2,945	0	0	0	-28,945
Scenario A 20% AB reduction	34,472	2,006	0	839	-33,306
Scenario A 50% AB reduction	43,267	5,014	0	2,083	-40,336
Scenario A 100% AB reduction	56,459	10,029	0	4,136	-50,567
Scenario B 20% AB reduction	28,945	2,006	6,000	839	-33,779
Scenario B 50% AB reduction	28,945	5,014	14,700	2,083	-40,714
Scenario B 100% AB reduction	28,945	10,029	27.600	4,136	-50,653

The changes in net costs are presented in figure 5.6. The figure shows that the most important costs are the avoidable disease costs and the costs for additional management measures. In the model it is assumed that when additional management measures are applied (scenario B) the morbidity and mortality rate stay at their current level. If we compare the increase in disease cost in scenario A with the increased cost of additional management measures in scenario B, we see the same pattern. The increase in net costs of scenario A and B are also comparable. So under the assumptions of the model, no additional management (scenario A) or investment in additional management measures (scenario B) does not make a big difference in terms of annual net costs.

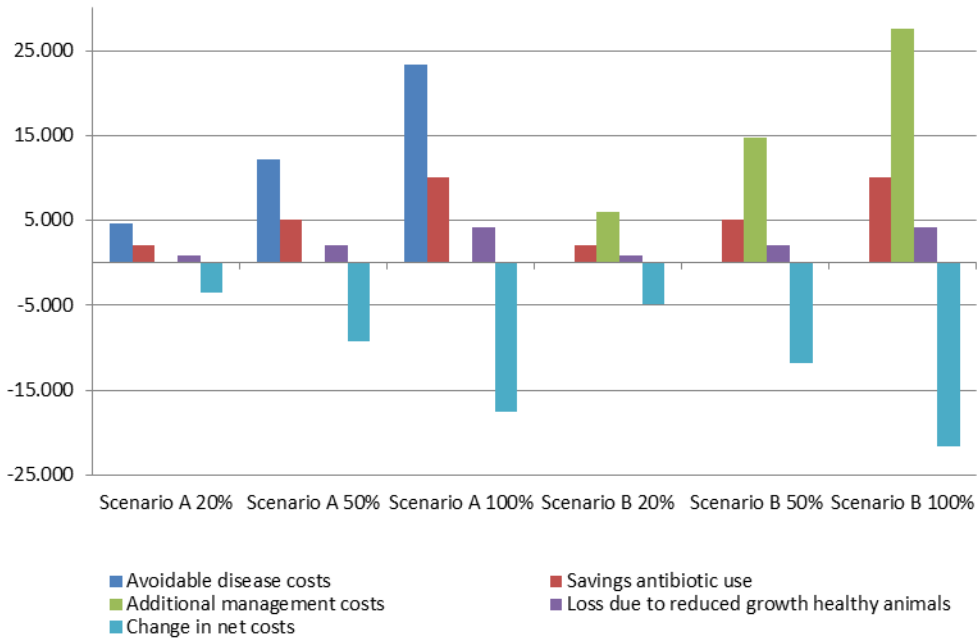

Figure 5.2 Changes in net costs for scenario A and B when antibiotic use is reduced.

Although in terms of annual cost there is no difference, additional health measures make a big difference in animal welfare. As a result of these measures the mortality and morbidity is assumed to decrease, compared to no additional animal health measures (scenario A). Investment in additional animal health measures is better in terms of animals welfare, and in terms of the annuals net costs scenario A and B are more or less the same. In the model the investment in additional animal health measures is calculated on an annual basis however, investment in these measures requires own capital or a loan.

Cost and benefits related to production costs

Reducing antibiotic use will result in an increase in production costs. In the model the net cost for a 20%, 50% and 100% reduction in antibiotic use are calculated for two scenarios. The increase in net costs for the scenarios are given in table 5.7. The changes in net cost are also given per 100 chickens per round.

Table 5.7 Calculated change in net costs compared to the current situation

	Δ Annual net costs (€)	Δ Net costs (€) per 100 chickens per round
Scenario A 20% AB reduction	-3,521	-0.09
Scenario A 50% AB reduction	-9,307	-0.25
Scenario A 100% AB reduction	-17,485	-0.46
Scenario B 20% AB reduction	-4,834	-0.13
Scenario B 50% AB reduction	-11,769	-0.31
Scenario B 100% AB reduction	-21,708	-0.57

The margin (saldo in Dutch) per 100 chickens per round for current situation is 15.85 euro (KWIN 2011). According to the model the margin per 100 chickens per round will decrease, depending on the scenario and level of antibiotic reduction, with 0.09 to 0.57 euro. The economic results of a general farm are given in table 5.8. The table shows that in the period between 2005 and 2010 the net farm result was mainly negative, only in 2005 and 2006 there was a small profit. The income from holding activities show some variation, with some good and bad years. The savings also show some variation between the years. These figures show that a further increase of the cost, which will be a result of antibiotic reduction, will decrease net farm result even more and could have a considerable negative effect on income.

Table 5.8 Economic farm results (LEI 2011)

	2005	2006	2007	2008	2009	2010
Net farm result (€)	8,700	-71,800	6,100	-53,600	-21,900	-51,800
Income from holding activity (€)	64,800	6,200	83,500	6,100	58,500	19,200
Savings (€)	30,900	-37,800	40,200	-36,600	6,600	-25,000

5.3 Economic effects on sector level

The costs and benefits for the sector as a whole are also calculated by the model. The calculation for the sector as a whole is done by assuming that the sector is uniform and that all the inputs are the same as for the average farm. The calculations are based on the total number of chickens per year of 44.747.900 (number of 2010) (LEI 2011). In the model the number determines the costs and benefits, so to calculate the effects for the sector as a whole the total number of chickens is used to calculate the economic effects. The sector is represented in the model as one big farm. The costs and benefits and the change in net costs, for the sector as a whole, are given in table 5.9a and 5.9b.

Table 5.9a Calculated annual costs and benefits of a reduction in antibiotic use

	Avoidable disease costs (€)	Savings antibiotic use (€)	Additional management (€)	Loss growth (€)	Net costs (€)
Current	2,398,590	0	0	0	-2,398,590
Scenario A 20% AB reduction	2,856,608	166,206	0	69,563	-2,759,965
Scenario A 50% AB reduction	3,585,352	415,516	0	172,641	-3,342,478
Scenario A 100% AB reduction	4,678,573	831,032	0	342,751	-4,190,291
Scenario B 20% AB reduction	2,398,590	166,206	426,170	69,563	-2,728,117
Scenario B 50% AB reduction	2,398,590	415,516	1,108,043	172,641	-3,263,758
Scenario B 100% AB reduction	2,398,590	831,032	2,088,235	342,751	-3,998,543

Table 5.9 b Calculated changes in net cost and avoidable disease costs

	Δ Net costs (€)	Δ Avoidable disease costs (€)
Scenario A 20% AB reduction	-291,812	388,456
Scenario A 50% AB reduction	-771,246	1,014,121
Scenario A 100% AB reduction	-1,448,950	1,937,232
Scenario B 20% AB reduction	-329,527	0
Scenario B 50% AB reduction	-865,168	0
Scenario B 100% AB reduction	-1,599,953	0

The avoidable disease cost for the current situation is calculated by the model at 2,398,590 euro. As a result of antibiotic reduction the avoidable disease cost increase to 2,856,608 euro (19% increase) when antibiotic use is reduced with 20%. When antibiotic use is reduced with 50% the avoidable disease cost increases to 3,585,352 euro (49% increase) and to 4,678,573 euro (95% increase) when antibiotic use is reduced with 100%. The savings of a reduction in antibiotic use ranges from 166.206 euro to 831,032 euro. The increase in net costs is given in table 5.9b. Depending on the scenario the annuals net cost for the sector as a whole ranges from 291,812 euro to 1,599,953 euro. Investment in additional management measures has a big share in the increase in annual net costs. Additional management measures consist of animal health measures and technical management measures. Investment in additional animal health measures is in the model on an annual basis. The annual costs are calculated by dividing the total investment by a lifespan of 12.5 years, the interest rate is not take in to account. The total investment of the additional animal health measures is give in table 5.10.

Table 5.10 Calculated total investment for additional animal health measures for the whole sector

	Scenario B reduction AB 20%	Scenario B reduction AB 50%	Scenario B reduction AB 100%
Investment in new drinkingwater system (€)	0	2,929,922	2,929,922
Investment new ventilation system (€)	0	0	6,658,914
Investment new floor heating and cooling system (€)	5,327,131	5,327,131	5,327,131
Total (€)	5,327,131	8,257,053	14,915,967

The total investment depends on the farms size, the bigger the farm the higher the investment. To invest in additional animal health measures a farmer needs own capital or a loan. Given the economic results of the farmers, as mentioned in the precious section (table 5.8), getting a loan could be a problem.

6 Conclusion and discussion

In this research a model is developed to calculate the economic effects of antibiotic reduction at broiler farms, on farm level and for the sector as a whole. The model calculates the costs of a 20%, 50% and 100% reduction in antibiotic use. An important part of the model is the calculation of possible additional disease costs. To calculate these costs data on the mortality, morbidity and prevalence of infection diseases is important. These data are present in datasets of animal health institutes but were not available for students, and thus not for this research. In absence of this data the model makes use of best guesses. The model should be seen as a first step in the research on the topic of antibiotic reduction in broiler farming. When data on the mortality, morbidity and prevalence of infection diseases becomes available the model can be used and modified to make a more precise estimation of the costs and benefits of antibiotic reduction in broiler farming.

The model estimated the net cost of antibiotic reduction for the average farm. The average farm is defined as farm with a shed capacity of 90,000 chickens which means 540,000 chickens per year. In statistical data sources also other numbers are given for an average farm, these numbers are based on the total number of chickens per year divided by the number of firms. Because also very small firms (less than 5,000 animals per year) are taken in to account in these statistics the average size is lower. However based on the literature, of mainly the LEI, the average farm is defined as a farm with a shed capacity of 90,000 producing 540,000 chickens per year.

Disease costs

This research shows that antibiotic use is a cheap measure to decrease the risk and the effects of diseases compared to alternatives like additional health management measures. In the model it assumed that antibiotic reduction increases mortality and morbidity of chickens and as a result disease costs. The model estimates that total disease cost for an average farm (90,000 chickens per production round) will increase with 4,688 euro (16%) when the antibiotic use is reduced with 20%. When antibiotic use is reduced with 50% disease cost will increase with 12,238 euro (42%) , and when antibiotic use is reduced with 100% disease cost increase with 23,378 euro (81%). The main part of the increase in disease costs is explained by the increased morbidity rate. The losses due to morbidity are 65 to70% of the total avoidable diseases cost. The sharp rise of the disease cost as the antibiotic use is reduced is explained by the assumption that the morbidity rate increases with the same percentage as the antibiotic use is reduced, so in the scenario of 50% antibiotic reduction it is assumed that the morbidity rate is 1.5 times the current rate. Because data of the effect of antibiotic reduction on mortality and morbidity is not yet available the model makes use of this assumption. If the effect of reduced antibiotic use on mortality and morbidity is lower than assumed, the increase in disease cost will be lower.

Additional management measures

The cost of additional management measures is high compared to the cost of antibiotics. In scenarios B of the model it is assumed that a farmer will take additional management measures to prevent and control disease. There are two types of measures in the model; changes in health management and changes in technical management. It is assumed that the higher the level of antibiotic reduction the more additional measures a farmer will take. In practice a farmer will make the decision which additional management measures to apply on the basis of a cost benefit analysis. The benefits of the additional management measures are unknown, future research should focus on this topic. Because the this, it is assumed in the model that the higher the level of antibiotic reduction the more additional measures will be taken by the farmer. Furthermore is assumed that as a result of these sets of additional measures the avoidable disease cost will stay at the current level. When data on the benefits is available a cost benefit analyses of the different measures can be made, and the sets of additional management measures can be updated according to the cost benefit analyses. Given the absence of this data the following is assumed in the model. When antibiotic reduction is reduced with 20% it is assumed that a farmer will invest in a new dinkingwater system. The annual cost this system are 6,000 euro, the total investment is 75,000 euro. When the level of antibiotics is reduced with 50% it is assumed that the farmer will invest in a new dinkingwater system, a new floor heating and cooling system and probiotics. The total annual cost of all these measures is 14,700 euro. The total investment in a new dinkingwater system and a new floor heating and cooling system is 116,250 euro. When antibiotic use is reduced with 100% it is assumed that, besides the measures that are already in the scenario for 50% reduction, a farmer will also invest in a new ventilation system and give extra vitamins. The annual costs of this package is 27,600 euro. The total investment in additional animal health measures (new dinkingwater, floor heating and cooling and ventilation system) for the scenario of 100% reduction is 210,000 euro. The costs of additional management measures are high, because the costs are based on total replacement. If systems are already in place the cost for additional management measures will be lower. Investments in additional animal health measures is high and requires own capital or a loan. Because the net farm result of broiler farming in general is low or even in some years negative (LEI, 2011), it is doubtful if farmers can get a loan to invest in additional management measures. Also given the current economic crisis, it is expected that for small and/or inefficient farms the investments will be too high. The set of measures that a farmer takes in the different scenarios is based on the assumption that a farmer will try to reduce the risk of disease as a result of antibiotic reduction. When the additional information on the effects of antibiotic reduction on mortality and morbidity and the reaction of farmers in terms of alternative disease prevention and control measures becomes available, the model can incorporate this information.

Savings reduced antibiotic use

Reducing antibiotic use result in a reduction of the cost for antibiotic treatment. The savings that can be made by reducing antibiotic use are low. A reduction of 20% in antibiotic use will reduce the cost of treatment with 2,006 euro. The cost will reduce with 5,014 and 10,029 euro if antibiotic use is reduced with a 50 and 100% reduction respectively. In the model the reduction in cost is estimated by calculating the total cost of treatment, and then reducing this cost by the percentage of antibiotic reduction. The savings include only the cost of antibiotics. The cost of a visit by a veterinarian or other cost related to antibiotic treatment are not taken in to account.

Economic effects for the average farm

This research shows that reducing antibiotic use will increase the cost of production. Depending on the scenario the net cost per chicken increase with 0,09 to 0,57 euro. These figures seem relatively low but margins in broiler farming are low and in some years even negative. A reduction in antibiotic use will affect not only the production cost but also family income. Investment in additional management measures is costly and it is doubtful if farmers can lend the capital to invest in these measures, given their financial position and the current economic crisis. Although it is costly it better to invest in measures to prevent and control diseases (scenario B) than accepting higher avoidable disease costs (scenario A). In terms of annual cost is does not make a big difference, but investment in additional management measures is better for animal welfare. With additional management measures in place mortality and morbidity will be lower compared to a situation without additional measures.

The model estimated the costs and benefits for the current situation and for scenario A (no additional management) and scenario B (additional management). The two scenarios are calculated for three levels of antibiotic reduction (20%, 50% and 100%). The costs are related to the current costs, to calculate the change in net costs. The net costs of all the scenarios are negative which indicates that a reduction in antibiotic use will increase the costs of production. The increase in net costs in scenario A is explained by the increase in disease costs. In scenario B the increase in net cost is explained by the high investment in additional management measures. Because data on the effect of antibiotic reduction on the health status (mortality and morbidity) is not available at the moment, it could be the increase in disease costs is lower than assumed. Related to the health status farmers could take additional management measures as an alternative to antibiotics. Because the policy is not enforced at the moment it is unknown how farmers will react and which additional measures they will take.

Economic effects on sector level

The net cost of a reduction in antibiotic use for the sector as a whole is negative. The annuals net costs range from 291.812 euro to 1.599.953 euro, depending on the scenario and level of antibiotic reduction. It should be noticed that these costs are annual costs and that in scenario B it is assumed that farmers will invest in additional management (animal health and technical management measures). Investment in additional animal health measures requires capital or a loan. The total investment in additional animal health measures is 14,9 million. Given the fact that the profit margins are low and the net farm results and savings of recent years were slightly positive but in most years negative, it is doubtfully whether these investment can be made.

Costs and benefits of antibiotic reduction

According to the model antibiotic reduction will result in an increase of the cost of production. The savings of antibiotic reduction are not high enough to cover the increase in costs. So there is no financial incentive for a farmer to reduce antibiotic use. However there are more incentives that drive a farmer than only finance. Antibiotic resistance is also a problem for farmers. If antibiotic treatment is no longer effective production losses will increase. Antibiotic reduction also fits in the movement of sustainable production. The incentive to give antibiotic treatment is not only to reduce production losses but also because of animal welfare and the treatment of a diseased animal. Reducing antibiotic use can therefore only be accomplished when there are good alternative to prevent and control diseases. These alternatives could be the additional management measures that are used in the model, but there may also be other alternatives. Future research should focus on the development of these alternatives and on measuring the effectiveness of these measurers.

In this research a model is developed to calculate the cost of a reduction in antibiotic use. The policy is not jet enforced at the moment so the effect of a reduction in antibiotic use is unknown. With this research a forecast is made of what the effect of a reduction in antibiotic use will be in terms of net cost. In the model assumptions are made on the effect a reduction in antibiotic use will have on mortality and morbidity. The calculation of these avoidable disease costs are an important part of the model. Future research should focus on measuring the effect antibiotic reduction will have on the health status of broiler chickens. Once this data is available the model can be modified to give a more precise estimation.

The model can also be used to calculate the net costs of a ban of one or more specific types of antibiotics. The model then needs to be modified in a way that it will calculate the net cost of these specific types of antibiotics instead of antibiotics in general as is done in this research. This will make the model usable to calculate the net cost of a ban of antibiotics that are used as a last treatment option in humans. A ban of these type of antibiotics for animal husbandry is recently advised by the Health Council of the Netherlands (Gezondheidsraad 2011).

This research should be seen as the first step to calculate the economic effect of antibiotic reduction on Dutch broiler farms. The effects of antibiotic reduction on the health status of chickens is unknown. Future research should focus on measuring these effects. Data needs to be gained on the effect reduction of antibiotic use will have on the morbidity and mortality of broiler chickens. In the model it is assumed that antibiotic reduction will result in a serious increase in morbidity and mortality, but it is unknown if this is the case. Investment in additional management measures has a big share in the increased net cost as they are calculated by the model. It is unknown to what extend additional management measures will be needed to keep the health status of the chickens at an acceptable level, and to what extend farmers will apply these measures. If the increase in mortality and morbidity, as a result of antibiotic reduction, will be minimal it is possible that there is no need to take additional management measures. Improvement of genetics could also play a role to reduce the negative effect of antibiotic reduction on the health status of broiler chickens and by that production. If as a result of genetic development the resistance of a chicken to bacterial infection will increase, the effect of a reduction antibiotic use on production cost could be minimal.

The main conclusion of this research is that according to the model a reduction in antibiotic use will result in an increase of the cost of production. Future research on the effect antibiotic reduction has on mortality and morbidity is needed to improve the model. Furthermore research on the development and efficiency of additional management measures and other methods to produce poultry meat without high levels of antibiotics is needed.

The costs and benefits of a reduction in antibiotic use in animal husbandry on the human health was not part of this research. However one of the reasons to reduce antibiotic use in animal husbandry is the negative effect high antibiotic use in animal husbandry is thought to have on successful antibiotic treatment in humans. Knowledge on this topic is useful when a political decision is made whether, and to what extent, a reduction in antibiotic use in animal husbandry is needed and acceptable. To come to a balanced political decision knowledge is needed on the benefits for human health of a reduction in antibiotic use in animal husbandry. However it is difficult to quantify the costs and benefits for human health. To quantify this the relation between antibiotic use in animal husbandry and failing treatment in humans has to be clear and the costs and benefits need to be quantified by using DALY's or QALY's. Future research could focus on this topic.

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