Animal welfare decisions in Dutch poultry and pig farms

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Abstract

The minimum level of animal welfare (AW) is guaranteed by EU and national legislation in most European countries. Within the current international economic and political environment further improvements in the welfare of farm animals predominantly rely on market initiatives. Market initiatives set requirements in terms of AW that exceed the legal minimum standards. Participation in a particular market initiative is a voluntary choice of the farmer. The overall objective of this dissertation was to analyze the factors that determine farmers' decision-making with regard to the implementation of AW standards and identify the potential means to mitigate barriers to adopt above-legal AW standards at farm level. In this dissertation farmers' decision-making is conceptualized as a process in which farmers trade off financial and non-financial goals. Financial goals relate to monetary aspects, whereas non-financial goals appeals to farmers' intrinsic motivation to improve AW. This dissertation suggests that broiler and fattening pig farmers do not have a strong intrinsic motivation to switch to a production system that provides higher level of AW than the minimum legal requirements. In this respect, at farm level certain financial preconditions have to be met to enable farmers to adopt higher AW standards. More specifically, farmers require a price premium that is at least sufficient to cover extra costs as a result of higher animal welfare standards. Furthermore, it is important to manage the (perceived) uncertainty of the market and price premiums. These imply that middle-market segment could be attractive for farmers due to its high cost-efficiency, i.e., realize the highest relative increase in AW at the lowest costs, which is also in the best interest of other stakeholders in the supply chain. Furthermore as switching to a middle-market system primarily affects variable costs farmers are given the flexibility to revert to the conventional system if their expectations are not met. Middle-market segment products, as they improve on many production attributes related to AW, may also offer alternatives for consumers that take many attributes into account to form an opinion of the animal friendliness of a production system. In the light of the foregoing, further development of the middle-market segment appears to be a reasonable direction in improving AW. In order to facilitate the further development of the middle-market segment a high involvement of all stakeholders in the supply chain, i.e., slaughterhouses, processors, retail, NGOs, and the government as well is required.

Contents

Chapter 1

General introduction

Background

Since the Second World War production of broilers, laying hens, and pigs enormously intensified, particularly in Western Europe, as reflected by the evolution of farm structural characteristics, productivity, and the degree of specialization in farming activities (Hendrickson and Miele, 2009). During the second half of the 20th century, the number of farms considerably decreased, which coincided with a substantial increase both in farm size and the number of animals kept in a farm. For example, the number of pigs in the Netherlands increased from 1.9 million in 1950 to 13.6 million in 1999 even though the number of farms with pigs decreased over that period from 271,000 to 16,000 (CBS, 2014a). Moreover, the productivity of animals extremely increased. The time required for the broiler chicken to reach a live weight of 1.8 kg decreased form 101 days in 1957 to 32 days in 2001 (Havenstein et al., 2003). Furthermore, agricultural modernization and the introduction of capital-intensive technology have led to the development of highly specialized farms that concentrate on a specific type of production such as pork meat or egg production.

Although the intensification of production had arguably a positive effect on food security, it also affected animal welfare (AW) and led to public concerns regarding animal production as of the early ’70s (Hendrickson and Miele, 2009; Miele et al., 2013). Following these concerns, minimum legal AW standards have been introduced in the European Union level which producers in all member states must comply with (Veissier et al., 2008). On top of the EU standards, some member states have implemented additional requirements to safeguard AW in their national legislation. Although in the European Union 60% of the citizens believe that AW has improved in their country since the mid- 1990s, 77% believe that there is a need for further improvements to be made in this field (European Commission, 2007). Also, consumers express their preferences towards further improvements in AW (Meuwissen and van der Lans, 2005; Vanhonacker et al., 2007; de Jonge and van Trijp, 2013b). The fact that consumer segments exist that are very concerned about AW and also segments that are less concerned or indifferent (Vanhonacker, 2007; Vanhonacker and Verbeke, 2009) implies that there is a need for a differentiated supply of livestock products. Hence, in the last decade a wide range of new market initiatives that supply livestock products which comply with AW standards higher than the legal minimum standards has developed, particularly in Western-European countries, such as France and the United Kingdom (Veissier et al., 2008; Oosterkamp et al., 2011; Vanhonacker and Verbeke, 2014). Also, in the Netherlands, conventional products have been criticized by society for the low levels of AW standards. As organic products are charged with a substantial price premium only a small segment of consumers considers them as viable alternatives. Hence, a middle-market segment has emerged to supply alternative products that go beyond the minimum AW standards and are affordable for a larger public (Bos et al., 2013). In the Dutch market a large part of middle-market products are marketed under the Better Life hallmark, introduced in 2007 by the Dutch Society for the Protection of Animals (DSPA), that defines criteria for AW. In 2012, about 1.1% of total number of broilers, 4.5% of total number of laying hens and 3.6% of total number of pigs were produced according to the criteria of Better Life hallmark (DSPA, 2014; CBS, 2014b). Hence, the market share of the middle-market segment is still relatively small in the Netherlands. Nevertheless, it can be hypothesized that a latent demand exists for products that are produced under welfare conditions that exceed legal requirements (Meuwissen and van der Lans, 2005; European Commission, 2007; Vanhonacker et al., 2007; de Jonge and van Trijp, 2013b).

The scientific understanding of the reasons that latent demand for animal-friendly products is not entirely translated into actual purchase behavior is still partial. Clearly, a differentiated supply that is needed to cater the heterogeneous consumer preferences can only be achieved as a joint, coordinated and simultaneous action of all stakeholders, because it introduces uncertainties and mutual dependencies along the chain (Immink et al., 2013). Therefore, the integrative aspects of the demand for animal-friendly products through the chain should be considered in the development of new AW initiatives. This concept has been addressed in an integrated research project entitled "Mobilizing the latent consumer demand for animal-friendly products" funded by the Dutch Organisation for Scientific Research (NWO). The project aimed to provide stakeholders with useful information on establishing production and retail strategies to facilitate market initiatives and to increase the probability of success of these initiatives. This integrated project included three individual subprojects. The first addressed the consumer level by elaborating on the extent to which consumers integrate moral concerns in their purchase behavior and by investigating consumers' response to different marketing instruments (de Jonge and van Trijp, 2013a; de Jonge and van Trijp, 2013b; de Jonge and van Trijp, 2014). The second focused on the development of chain-level strategies to increase their effectiveness in mobilizing the latent demand for animal friendly products (Bos et al., 2013). The third addressed farmers' decision-making related to implementation of AW standards. The research described in this dissertation elaborates on the latter area, i.e., how farmers respond to market developments and which factors determine farmers' response.

Problem statement

Within the current international economic and political environment further improvements in the welfare of farm animals predominantly rely on the introduction of market initiatives that set AW requirements that exceed the legal minimum standards (Vanhonacker and Verbeke, 2014). Hence, participation in a particular market initiative is a voluntary choice of the farmer. So far, the production is focused on bulk demand, meeting standard legal and chain requirements, for chicken and pork meat rather than reaching consumer segments requiring niche products. Given that a latent demand exists for products with higher welfare (compared to the mainstream products) (Franz et al., 2010), there is still scope for increasing production of animal-friendly products.

Most farmers are reluctant to implement new production systems and practices which provide more welfare to their animals. This reluctance can be a result of both objective factors, such as financial benefits and financial risk associated with a new production system, and subjective elements, such as farmers' perception of financial risk and farmers' moral and social goals (Edwards-Jones, 2006). A knowledge gap pertains to farmer's subjective trade-offs between financial benefits, and risk considerations associated with the implementation of animal-friendly practices and systems, and farmers' moral and social goals. Knowledge on these issues is essential to identify barriers to adoption of increased AW standards in the farm, which is needed to increase supply that could potentially address the latent demand for AW products.

Objective

The overall objective of this dissertation was to analyze the factors that determine farmers' decision-making with regard to the implementation of AW standards, and to identify barriers to the adoption of above-legal AW standards at farm level. The results of the study were used to discuss the potential means to mitigate the barriers to adoption and derive implications to provide basis for market stakeholders and government for developing guidelines further concept development.

To achieve the overall objective, four sub-objectives were defined:

1. to develop a conceptual framework of farmers' decision-making with regard to implementation of AW standards and present an approach to empirically implement the framework;

2. to identify farmers' preferences about AW standards, with special reference to farmers' intrinsic motivation to improve AW ;
3. to analyze farmers' choice of production system and identify potential barriers to the adoption of production systems with higher AW standards;
4. to analyze the financial impact and feasibility of implementing various AW standards in the farm.

Outline of the dissertation

This dissertation consists of a general introduction (**Chapter 1**), six research chapters (**Chapter 2-7**), and a general discussion (**Chapter 8**). The structure of the dissertation is presented in Figure 1.1.

Chapter 2 presents a conceptual approach to address farmers' decision-making related to implementation of AW standards. This chapter establishes the context of on-farm decision making regarding AW and elaborates the theoretical basis for the approach. Thereafter, an illustration for the empirical implementation of the conceptual approach is presented.

Chapter 3 explores broiler and fattening pig farmers preferences related to AW standards.

Chapter 4 addresses broiler and fattening pig farmers' choice-making related to implementation AW standards with particular emphasis on the trade-off between preferences and income. This chapter elaborates on the issue under what conditions farmers are willing to convert to more animal-friendly systems.

Chapter 5 develops a stochastic bio-economic simulation model to simulate the effect of financial and business risk on the technical and economic of different broiler production systems, which differ in the assumed level of AW, over a five-year time horizon. In this chapter, the key drivers of economic feasibility of broiler production systems are identified. A scenario analysis is carried out to analyze the effect of price premium on the economic feasibility of various broiler production systems.

Chapter 6 develops a partial budgeting model to analyze the effects of different broiler production systems on health care costs. The absolute and relative effect of various diseases on production costs were analyzed.

Chapter 7 compares three intensive livestock production sectors, i.e., broiler, laying hen, and fattening pig, in terms of economic feasibility of selected production systems using the modelling approach developed in Chapter 5. This chapter also analyses the riskiness of implementing different production systems with special reference to the degree of reversibility of the investment.

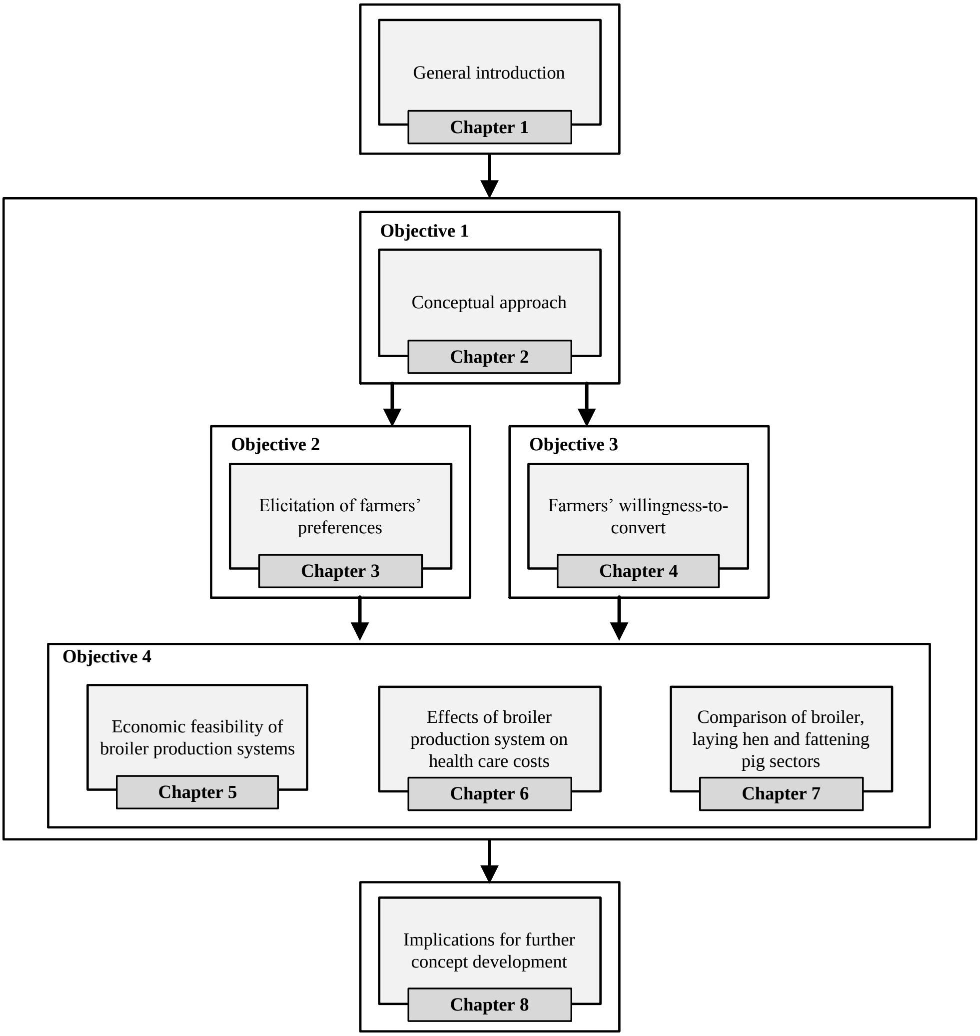

Figure 1.1 Structure of the dissertation

Finally **Chapter 8** discusses the overall results in a wider context, elaborates implications for business stakeholders and policy makers, reflects on the approaches methods used in this dissertation, outlines directions for future research, and finishes with the main conclusions of the dissertation.

References

Bos, J.M., Blok, V., van Tulder, R. (2013). From Confrontation to Partnerships: The Role of a Dutch Non-Governmental Organization in Co-Creating a Market to Address the Issue of Animal Welfare. International Food and Agribusiness Management Review, 16:69-75.

CBS. (2014a). Statistics Netherlands. Available at http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=71904NED&D1=6,45&D2=99,148&VW=T. Accessed 09-07-2014.

CBS. (2014b). Statistics Netherlands. Available at http://www.cbs.nl/nl-NL/menu/home/default.htm. Accessed 09-07-2014.

De Jonge, J., van Trijp, H.C.M. (2013a). The impact of broiler production system practices on consumer perceptions of animal welfare. Poultry Science, 92:3080-3095. DOI: 10.3382/ps.2013-03334.

De Jonge, J., van Trijp, H.C.M. (2013b). Meeting Heterogeneity in Consumer Demand for Animal Welfare: A Reflection on Existing Knowledge and Implications for the Meat Sector. Journal of Agricultural and Environmental Ethics, 26:629-661. DOI: 10.1007/s10806-012-9426-7.

De Jonge, J., van Trijp, H.C.M. (2014). Heterogeneity in consumer perceptions of the animal friendliness of broiler production systems. Food Policy, 49:174-185. DOI: 10.1016/j.foodpol.2014.07.008.

DSPA. (2014). Jaarrapport Beter Leven kenmerk 2007-2010 (Annual report Better Life hallmark). Dutch Society for the Protection of Animals, The Hague, the Netherlands. Available at http://www.jandobbe.nl/fileupload/Ieder_jaar_een_beter_leven_voor_steeds_meer_dieren.pdf. Accessed 09-07-2014.

Edwards-Jones, G. (2006). Modelling farmer decision-making: concepts, progress and challenges. Animal Science, 82:783-790. DOI: 10.1017/Asc2006112.

European Commission. (2007). Attitudes of EU citizens towards Animal Welfare. Avaialable at http://ec.europa.eu/public_opinion/archives/ebs/ebs_270_en.pdf. Accessed 03-08-2014.

Franz, A., von Meyer, M., Spiller, A. (2010). Prospects for a European animal welfare label from the german perspective: Supply chain barriers. International Journal of Food System Dynamics, 1:318-329.

Havenstein, G., Ferket, P., Qureshi, M. (2003). Growth, livability, and feed conversion of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. Poultry Science, 82:1500-1508. DOI: 10.1093/ps/82.10.1500.

Hendrickson, M., Miele, M. (2009). Changes in agriculture and food production in NAE since 1945. Pages 20-79 in Agriculture at crossroad. B. D. McIntyre, H. R. Herren, J. Wakhungu, and R. T. Watson eds. IAASTD North America and Europe, World Bank, Island Press, Washington DC, USA.

Immink, V.M., Reinders, M.J., van Tulder, R.J.M., van Trijp, J.C.M. (2013). The livestock sector and its stakeholders in the search to meet the animal welfare requirements of society. Journal on Chain and Network Science, 13:151-160. DOI: 10.3920/jcns2013.1005.

Meuwissen, M.P.M., van der Lans, I.A. (2005). Trade-offs between consumer concerns: An application for pork supply chains. Food Economics - Acta Agriculturae Scandinavica, Section C, 2:27-34. DOI: 10.1080/16507540510033442.

Miele, M., Blokhuis, H., Bennett, R., Bock, B. (2013). Changes in farming and stakeholder concern for animal welfare in Improving farm animal welfare. Science and society working together: the Welfare Quality approach. H. Blokhuis, M. Miele, I. Veissier, and B. Jones eds. Wageningen Academic Publishers, Wageningen.

Oosterkamp, E.B., Bremmer, B., Hoste, R., De Greef, K.H. (2011). Verkenning van dierlijke tussensegment in onze buurlanden: Duurzaam varkensvlees, pluimveevlees en eieren, LEI-rapport 2011-028 (in Dutch with English summary). LEI-Wageningen UR, The Hague, the Netherlands.

Vanhonacker, F., Verbeke, W. (2014). Public and Consumer Policies for Higher Welfare Food Products: Challenges and Opportunities. Journal of Agricultural and Environmental Ethics, 27:153-171. DOI: 10.1007/s10806-013-9479-2.

Vanhonacker, F., Verbeke, W., van Poucke, E., Tuyttens, F.A.M. (2007). Segmentation Based on Consumers' Perceived Importance and Attitude toward Farm Animal Welfare. International Journal of Sociology of Agriculture and Food, 15:91-107.

Veissier, I., Butterworth, A., Bock, B., Roe, E. (2008). European approaches to ensure good animal welfare. Applied Animal Behaviour Science, 113:279-297. DOI: 10.1016/j.applanim.2008.01.008.

Chapter 2

A conceptual approach for a quantitative economic analysis of farmers' decision-making regarding animal welfare

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Abstract

Decisions related to animal welfare (AW) standards depend on farmer's multiple goals and values and are constrained by a wide range of external and internal forces. The aim of this paper is twofold, i.e., (1) to develop a theoretical framework for farmers' AW decisions that incorporates farmers' goals, use and non-use values and (2) to present an approach to empirically implement the theoretical framework. The farmer as a head of the farm household makes choices regarding production to maximize the utility of the household. The overall utility of the farmer is determined by his multiple objectives. For the analysis of multi-objective problems, the multiple criteria decision-making paradigm provides an appropriate theoretical framework. However, theories from the field of social-psychology are needed to facilitate the identification of all relevant aspects in the decision making (i.e., factors that explain behavior). The practical use of the conceptual framework is demonstrated using a simple numerical application of a multi-objective programming model. Two workshops were devoted to examining the scientific consistency and the practical usefulness of the approach. Implementing this approach will increase knowledge of the main factors and barriers that determine farmers' decisions with regard to AW standards. This knowledge is relevant during the development of new AW concepts that aims to supply products that comply with above-legal AW standards for middle-market segments.

Keywords: Animal welfare, Economic decision-making, Barriers to adoption, Trade-offs, Farmers' decision support

Introduction

In the last 30 years, public concerns related to animal welfare (AW) have increased, particularly in North Western Europe (Bennett, 1996; Harper and Makatouni, 2002). A vast majority of European citizens (around 77 %) believes that the welfare and the protection of farm animals need to be improved within the EU (European Commission, 2007). The importance of animal welfare is recognized by consumers and market segments exist that take into account animal welfare to different degrees when purchasing food (Bracke et al., 2005; Meuwissen and van der Lans, 2005). Vanhonacker et al. (2007) stress the potential market opportunities related to animal welfare for high welfare products.

The increasing AW concerns have induced a stream of studies on the technical and ethological aspects of AW (Appleby, 2003; Anonymous 2, 2004; Anonymous 4, 2004; Tauson, 2005; Anonymous 1, 2008; Anonymous 3, 2010; Bonafos et al., 2010). In the Netherlands, stakeholders in the animal supply attempted to improve AW and to induce consumers to choose animal-friendly products that comply with above-legal AW standards[1] specified in market initiatives (e.g., Volwaard, Rondeel, Scharrel, and Better Life hallmark[2]). These initiatives, in turn, aimed to develop middle-market segments that include animal-friendly products that comply with above-legal AW standards. Farms that have to comply with above-legal AW standards generally need to introduce AW improving technologies on their farms. These technologies differ in their characteristics (e.g., capital requirements, time horizon, and skill level to manage). Farmers can choose the ones that fit within the limits of their possibilities. Consumers can, in turn, choose from a wider assortment of animal-friendly products based on their own preferences. However, both the adoption by farmers of animal friendly practices and the success of animal-friendly products in markets have been small so far.

Clearly, the success of AW initiatives depends not solely on consumer demand, but also on farmers' willingness to participate in such initiatives. However, research has mainly focused on consumer demand by investigating consumer preferences and the consumers' willingness-to-

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[1] Above-legal AW standards exceed the minimum national legislative standards with regard to keeping of farm animals.

[2] Volwaard is an innovative production system for broilers providing higher AW than intensive systems. The Rondeel and Scharrel concepts are designed for laying hens and exceed legal AW standards. The Better Life hallmark (in Dutch: Beter Leven kenmerk) initiated by the Dutch Society for the Protection of Animals (Dierenbescherming) is intended to stimulate farmers to improve on-farm animal welfare by enabling a transparent differentiation among animal products in terms of AW.

pay (Nocella et al., 2010; Lagerkvist and Hess, 2011). Research on farmers' decision-making rarely goes beyond the analysis of mere financial aspects as factors that determine farmers' decisions (Darnhofer et al., 2005). The costs of AW (Den Ouden et al., 1997; Vosough-Ahmadi et al., 2011; Hudson, 2010), the relation between AW and farm profitability (Stott et al., 2005; Verspecht et al., 2011), and the attitudes and perceptions of farmers toward AW (Austin et al., 2005; Hubbard et al., 2007; Kjærnes et al., 2009) have all been investigated, whereas non-financial aspects such as moral goals, personal values, and attitudes toward risk have received little attention so far. Understanding of the farmers' decision-making (e.g., goals, trade-offs, and type of farmers), evaluating their preferences and gaining insight into the main factors and barriers determining farmers' AW decisions are crucial for the success of future market initiatives.

Lagerkvist et al. (2011) were the first to address non-financial issues in farmer's decision-making related to on-farm animal welfare standards. They provide a theoretical basis for future research to address farmer's trade-offs in AW decisions. They argue that not only consumers, but also farmers assign non-use values to animal production. Use and non-use values contribute to the farmer's overall utility. They nest the farmer's choice problem between competing levels of animal welfare (as a non-use value) and productivity (as a use value) in a model that maximizes farmer's utility subject to technological, budgetary, and legislative constraints. They conclude that the framework of farm household production model is well-suited to theoretically evaluate farm animal welfare policies and that more empirical applications are needed.

A logical subsequent step is to use the approach in practical decision support. However, a further development of the approach presented by Lagerkvist et al. (2011) faces problems due to the utility-based nature of the approach and the decision context. In most cases, farmers exhibit a non-linear preference for attributes, which means that utility functions have to be used to evaluate attributes (Hardaker et al., 2004). While elicitation of utility functions is already in itself complicated, the decision context makes this procedure even more complicated. Market concepts are initiated by external parties, not by the farmers. Farmers are offered a limited number of decision options, not necessarily including the option with the highest utility for the farmer. In other words, constraints are put on the farmers' decision problem which are not fully addressed by Lagerkvist et al. (2011). A theoretically consistent approach requires the elicitation of utility functions for each individual farmer that may consider adoption of AW practices. It is a tedious procedure for farmers and the burdens will outweigh the benefits, because middle-market segments will not allow the development of tailor-made market concepts for each individual farmer.

On the basis of these arguments, practical implementation of the Lagerkvist concept is hampered. Hence, the challenge is to use the Lagerkvist concept as a scientific basis to develop an approach that can be practically used. Furthermore, although the Lagerkvist approach addresses the trade-off between use values and the level of AW, it does not recognize the relevance of the farmer’s values and goals in the decision-making which may explain the actual behavior. For a comprehensive analysis, the farmer’s values and goals should be incorporated allowing for a better understanding of the decision-making.

The aim of this paper is twofold, i.e., (1) to develop a theoretical framework for farmers’ AW decisions that incorporates farmers’ goals, use, and non-use values and (2) to present an approach to empirically implement the theoretical framework. The conceptual approach is evaluated in terms of scientific credibility, consistency with decision-making in practice and usability in scientific analysis. While the approach conforms to the basic theoretical model established in the paper of Lagerkvist et al. (2011), it broadens this model and addresses the empirical challenges outlined previously. The remainder of the paper is structured as follows. The context of on-farm decisions regarding AW is described in ‘‘The Context of On-Farm Decisions Regarding Animal Welfare’’ section, followed by the theoretical basis for the approach in ‘‘Theoretical Economic Basis for the Approach and Conceptual Elaboration’’ section. In ‘‘A Conceptual Approach for the Quantitative Economic Analysis of Farmers’ Decision-Making Regarding Animal Welfare’’ section, the empirical approach is presented and ‘‘Conclusions’’ section concludes.

The Context of On-Farm Decisions Regarding Animal Welfare

The context of farmers’ AW decision-making limits the range of potentially suitable theoretical approaches and methodologies that can be used to develop a conceptual approach for AW decisions. As a result, the description of the context is important for elaborating the conceptual approach. The most important features of the context are briefly described in this section.

Decisions on animal welfare usually fall under the scope of strategic or tactical decisions. Decisions related to AW standards depend on farmer’s goals and values and are constrained by a wide range of external and internal forces (David, 2001).

Strategic and Tactical Decisions

AW decisions are major decisions that affect housing, management, feeding, technical performance, and marketing. In most cases, these decisions are strategic decisions that change the farm set-up and have a long time horizon (e.g., in terms of depreciation) (Mintzberg et al., 1976; Fredrickson, 1984; David, 2001; De Wit and Meyer, 2004; Capon, 2008). Uncertainty, irreversibility, and imperfect or conflicting information are factors associated with strategic decisions. All these factors may make farmers (even risk-neutral farmers) more reluctant to adopt new products and processes (Ghadim and Pannell, 1999; Pannell, 2003). Although strategic decisions are likely to entail larger progress in terms of on-farm AW than tactical decisions, they are also likely to be more risky than tactical decisions. Hence, farmers' risk attitudes play a more important role in strategic decisions.

Tactical decisions, i.e., altering relevant management routines rather than adopting a completely new production system, could be a favorable way to deal with the irreversible nature of strategic decisions and the uncertainty associated with a new system implementation. AW can also be improved by implementing tactical decisions, which in principle pertain to decisions per production cycle, e.g., roughage, different diets, and toys (Sørensen et al., 2001). These measures can improve AW, and most of them can be implemented without long-term investments or any major increase in workload (Sørensen et al., 2001). Concepts that can be adopted in a step-wise manner, thus providing farmers with sufficient experience to facilitate a complete alteration of their systems, are receiving more attention in market initiatives e.g., Better Life hallmark in the Netherlands.

Multi-objective Decision Problem

Farmers consider several attributes of the various decision alternatives, and they are normally motivated by multiple, often conflicting goals when they decide on the adoption of AW-friendly systems. Although, in modeling farmer decision-making, goals are classified under a number different headings, the basis for classification is similar. That is, to distinguish between goals that reflect more materialistic considerations and those that reflect personal, social and moral values. Distinction is often made between financial and non-financial factors or pecuniary and non-pecuniary goals (Edwards-Jones et al., 1998; Olsen and Lund, 2011). Lagerkvist et al. (2011) distinguish between use values and non-use values related to AW that determine farmer's AW decisions. The concept of non-use values refers to the value that farmers derive from the livestock independent of any current or future use that animals provide. However, the latter categorization may not cover the whole spectrum of relevant factors in farmer decision-making. In other words, use and non-use values may not fully explain the actual behavior. To expand the range of variables that affect farmer's choice a distinction has been made between (1) financial goals, that relate to the economic performance of an alternative, and (2) non-financial goals, that reflect the underlying moral and ethical concerns of an alternative, personal values, and peer group pressure.

External and Internal Forces

A range of external and internal forces have been described as factors that generally affect the strategic decision making process. Some forces, however, are especially important in the analysis of AW decisions, because these limit farmer's decision options. Table 2.1 categorizes external and internal forces in terms of importance in the analysis of AW decisions.

External forces are by definition beyond the control of a single farmer. In AW decisions, a stable and secure customer base and the potential price premium on the market are of significant relevance similarly to decisions related to organic farming (Padel, 2001). Increasing attention and public concerns related to on-farm animal welfare need to be considered, meanwhile accounting for environmental considerations (e.g., NH_3-emission in outdoor production systems). Institutional barriers, such as regulations at the national and European Union levels, certification constraints, quality standards set by the industry need to be considered. Available technological options determine the behavior and limit the choices of farmers.

Internal forces concern issues such as management, marketing, finance, and production within the farm. Farm-specific factors, such as farm size, the location of the farm, and life cycle of the farm, have implications for the technical and economic performance of the farm (De Buck et al., 2001; Padel, 2001; Pietola and Oude Lansink, 2001; De Lauwere, 2005). The technical and economic performance in turn determine the profitability of investments, solvency, liquidity, and net profit of the farm, all of which are important criteria in investment decisions (Oude Lansink et al., 2001; Aramyan et al., 2006). Farmers form a heterogeneous group in terms of their motivations, goals and values related to AW. Motivations, goals and values may be derived from the farmer's own personal characteristics, e.g., age, skill level of farmer, and capacity and ability to learn (De Buck et al,. 2001; Hall and Khan, 2003), but may also be related to the farm family, e.g., family size, availability of a successor (Wallace and Moss, 2002; De Lauwere, 2005; Farmar-Bowers and Lane, 2009). Age, skill level of the farmer and the availability of a successor are linked to the life-cycle of the farmer and, consequently, to the life-cycle of the family (Oude Lansink et al., 2001). The life-cycles of the farmer and the family determine the length of the time horizon that can be taken into account for investments. A longer time horizon implies that the future costs and benefits of investments are discounted over a longer period, a consideration that may increase the profitability of investments.

Table 2.1 Emphasis on different factors in AW decisions

	General emphasis	Specific emphasis
External forces		
Economic		
Stable and secure customer base	+	+
Price premium on the market	+	+
Social, cultural, demographic, environmental		
Public pressure	+	+
Cultural	+	+
Demographic	+	
Environmental	+	+
Political, legal, governmental		
National regulations	+	+
EU regulations	+	+
Sector initiatives (quality standards)	+	+
Technological	+	+
Internal forces		
Farm		
Farm size, scale of production	+	
Location of the farm	+	
Financial position of the farm	+	
Life cycle of the farm	+	
Farmer		
Personality traits	+	+
Social and moral goals, values	+	+
Risk attitude and perception	+	
Age (and life-cycle) of farmer	+	
Life-cycle of the family (having a successor)	+	
Skill level of farmer	+	+
Ability to manage new technology, practices	+	+

Theoretical Economic Basis for the Approach and Conceptual Elaboration

The farmer as a head of the farm household makes choices regarding production to maximize the utility of the household (Lagerkvist et al., 2011). The overall utility of the farmer is determined by his multiple objectives. For the analysis of multi-objective problems, the multiple criteria decision-making (MCDM) paradigm provides an appropriate theoretical framework. The paradigm links technological performance information with decision criteria and weights elicited from decision-makers, allowing the quantification of the trade-offs involved in the decision-making process. However, theories from the field of social-psychology are needed to facilitate the identification of all relevant aspects in the decision making (i.e., factors that explain behavior).

Multiple Criteria Decision-Making Paradigm

The MCDM framework assumes a rational decision maker who chooses one of the alternatives based on two or more criteria or objectives (Rehman and Romero, 1993; Wallenius et al., 2008). Basically, MCDM models can be divided into two categories: (1) multi-objective optimization and (2) multi-attribute utility theory (Qiu, 2005). Multi-objective optimization methods determine optimal solutions over continuous solution spaces. Multi-attribute utility theory refers to problems that are solved over a discrete decision space, ranking a few predetermined decision alternatives and selecting the best alternative based on multiple decision criteria (Qiu, 2005). Both models are quantitative methods, requiring the decision maker's preference structures either explicitly or implicitly, and solve the decision problems through optimization (Dyer et al., 1992). For the analysis of AW decisions, we favor multi-objective optimization because during multi-attribute utility theory, elicitation of a multi-attribute utility function that represents the farmer's preferences is necessary. Elicitation of multi-attribute utility function that takes into account all decision criteria and their interrelations is a complex exercise and very time-consuming for the decision-maker (Clemen and Reilly, 2001). In contrast, multi-objective optimization allows for different methods to account for farmer's preferences instead of using an explicit functional form of utility.

Social-Psychological Theories

The MCDM paradigm does not offer a proper methodology to assess all relevant aspects in decision-making. However, social-psychological theory allows for a comprehensive identification of relevant objectives in the decision-making process, an essential step in the operationalization of the multiple criteria decision-making paradigm. Social-psychological theories focus on variables that help to explain why some members of a given population exhibit a given behavior while other members of the same population do not (Fishbein et al., 2001). The variables in social-psychological theories take the form of goals, values and attitudes that are reflected in the farmer's preferences or multi-attribute utility function representing the performance or non-performance of any behavior. Two theories describe the field of social-psychology, and these together allow for a comprehensive assessment of relevant attributes in the decision-making. The theory of planned behavior (TBP) is one of the most widely used social psychological models for prediction of intention and behavior (Ajzen and Fishbein, 1980, 2008; Ajzen, 1991). The norm activation theory (NAT) defines personal norms (also referred as moral norms) as self-expectations that are based on internalized values (Schwartz, 1968, 1977).

The TPB is chosen as the basis of the social-psychological approach to identify all relevant objectives in the decision making process because the TBP has the potential to assess basic factors and motives relevant to the behavior of farmers. However, the TPB has to be extended to cover all factors in AW decisions. First, it has been found that moral obligation is a necessary part of the Fishbein–Ajzen model to predict behavioral intentions effectively in moral situations, such as AW decisions (Gorsuch and Ortberg, 1983; Ajzen, 1991; Beedell and Rehman, 1999). Personal norms, defined in the NAT to express the feeling of moral obligation, could be an additional component to the TPB. Second, it is often claimed that the total effect of past behavior is not mediated by the predictors in the TBP (Bergevoet et al., 2004; Ajzen and Fishbein, 2005). Indeed, in the TBP, past behavior is not part of the attitude concept even though the tripartite theory posits past behavior as one of the three essential components of attitude, alongside cognition and affect (Fishbein and Ajzen, 1975; Eagly and Chaiken, 1993). Thus, many different operationalizations of attitude exist in the literature. Aspiring to parsimony in our approach, we claim that attitude is affected by past behavior, and it is therefore not necessary to include past behavior as a separate component.

To conclude, the TPB, supplemented by the aspects described above, provides a basic structure for the identification of the relevant aspects (i.e., decision-making criteria) related to AW decisions, as shown in Figure 2.1.

The approach is structured as follows. There are four main categories of variables in the approach: (1) Personal Norms, (2) Attitude, (3) Subjective Norm, and (4) Perceived Behavioral Control. Variables within these categories determine the behavior directly or indirectly through the behavioral intention.

1. ‘Personal Norms’ is a category conceptualized as a feeling of moral obligation (Schwartz, 1968, 1977; Manstead, 2000). That is, some farmers think that animals fare well as long as they are not ill and as long as they grow and reproduce. Other farmers, however, think that beyond health and proper functioning, allowing animals to live their lives in a way that suits their biological nature forms a necessary part of good welfare (Verhoog et al., 2004).
2. ‘Attitude’ refers to the evaluations of a behavior based on material, social, and psychological payoffs along a dimension of favor or disfavor, good or bad, like or dislike (Harland et al., 1999; Ajzen and Fishbein, 2000). For example, if the farmer aims for

maximum productivity, he probably does not have a positive attitude toward the adoption of animal welfare systems. That is because these systems usually do not allow maximum utilization of resources (e.g., fewer animals per m^2 than in intensive production systems). Attitude can influence behavior directly or be mediated by goals and objectives (Willock et al., 1999). Table 2.2 classifies a farmer's goals and values under four main headings, similar to the scheme of Gasson (1973) (Austin et al., 1996; Ohlmer et al., 1998; Edwards-Jones et al., 1998; Willock et al., 1999; Bergevoet, 2005; De Lauwere, 2005; Nuthall, 2010). Instrumental values imply that farming is viewed as a business to obtain income and security. Intrinsic values reflect farming as an activity in its own right. Social values cover the importance of interpersonal relationships. Expressive values refer to farming as a means of self-expression or personal fulfillment. Farmers formulate beliefs about the performance of decision options in terms of these values and goals.

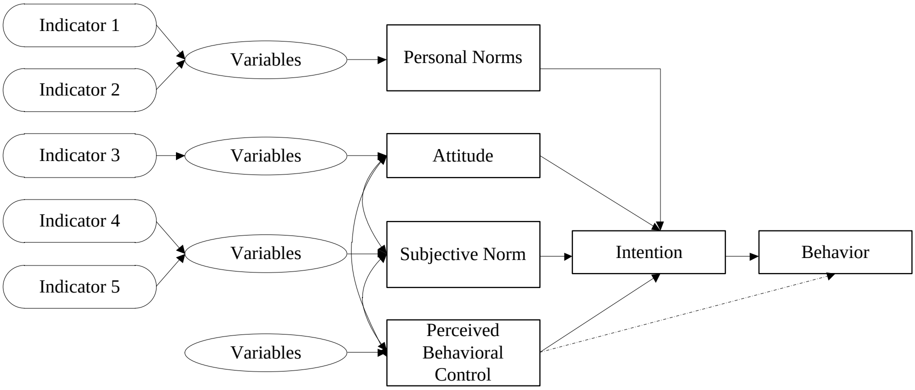

Figure 2.1 Conceptual theoretical basis (adapted from Ajzen, 1991)

3. 'Subjective Norm' refers to the opinion of important others and their attitude towards the behavior (Ajzen, 1991). It reflects the farmer's social environment and the extent to which farmers perceive themselves as members of this environment. For example, farmers who are more eager to meet the expectations of their social environment may join a group where they can work on these demands together with other farmers.
4. 'Perceived Behavioral Control' reflects farmers' capability and capacity to act, the availability of resources and facilities, and the perception of how all factors together facilitate performing a certain behavior (Ajzen, 1991). It can be observed at three levels: (1) that of individual (farmer), (2) at the organizational level (Farmar-Bowers and Lane),

Table 2.2 Farmer's goals and values

Instrumental	Intrinsic	Social	Expressive
Maximum profit/ income[1,2]	Enjoyment of work tasks[1]	Gaining recognition, prestige as a farmer[1]	Feeling pride of ownership[1]
Satisfactory income[1]	Preference for healthy, outdoor, farming life[1]	Belonging to the farming community[1]	Gaining self-respect for doing a worthwhile job[1]
Have liquidity enough not to be worried about paying[2]	Purposeful activity, value in hard work[1]	Continuing the family tradition[1]	Exercising special abilities and aptitudes[1]
Secure farm continuity[3]	Independence – freedom from supervision and to organise time[1]	Keep and improve the farm[2]	Chance to be creative and original[1]
Provide congenial working conditions – hours, security, surroundings[1]	Control in variety of situations[1]	Working with other members of the family[1]	Meeting professional challenge, achieving an objective, personal growth[1]
Expanding the business[1]	Having a farm on his own[2]	Maintaining good relations with workers[1]	
	Keep leisure time at previous level[2]	Having social contacts[2]	

[1] Gasson, 1973

[2] Ohlmer et al., 1998

[3] Schoon and te Grotenhuis, 2000

and (3) at the external level (environment). The valuation of perceived behavioral control comes down to questions at all three levels, such as ''Can I manage a new system with acceptable risk?'', ''Do I have the financial resources required to facilitate a secure adoption?'', and ''Is the current legislative environment in favor of adoption?''.

Assessment of the Scientific Credibility and Consistency with Decision-Making in Practice

An important part of building a conceptual model is to assess whether the conceptual model is valid for the intended purpose (Law and Kelton, 1991; Law, 2005; Sargent, 2007). Face validation, i.e., when experts are consulted, is recommended for checking whether the model adequately represents the system, i.e., the conceptual validity of the model (Garner and Hamilton, 2011). This technique was used in two consecutive workshops. In the first workshop, the focus was on the scientific consistency and credibility, and involved a panel of five scientists: two scientists in the field of economics (with an expertise in microeconomics, agricultural economics, and agricultural policy) and three in the field of choice behavior (psychology, marketing, and consumer studies). In this way, the scientific area of decision-making was covered. First, a short presentation was given in which the theoretical basis for the approach was explained. Thereafter, the panel was asked to reflect on the theoretical basis of the approach, i.e., they were asked to assess whether the model's assumptions were correct, complete, and consistent with the state-of-the-art scientific findings. Initially, the social-psychological approach included ''past behavior'' as a separate component. However, the panel suggested including it as a part of the attitude concept, rather than as a separate component and it was done accordingly. Second, the conceptual approach was presented to the scientists. They were asked if the analysis of AW decisions was feasible based on this approach. The panel agreed that the methods were compatible with each other, and they shared the opinion that the conceptual approach enabled a quantitative analysis of AW decisions. The second workshop included a panel of four farm advisors, all involved in strategic decision support. They also were presented with the approach and details were discussed in detail. They were asked to evaluate whether the list of categories (i.e., personal norms, attitude, subjective norm, perceived behavioral control) was complete and covered all aspects that should be taken into account during the analysis of AW decisions. They had no major objections or comments in this respect.

On the basis of both workshops, we concluded that the underlying theoretical model is scientifically consistent and credible, and the conceptual approach is suitable for analysis of AW decisions.

A Conceptual Approach for the Quantitative Economic Analysis of Farmers' Decision-Making Regarding Animal Welfare

Conceptual Approach

The analysis of a multi-objective decision problem is usually broken down to five different steps (Hardaker et al. 2004):

1. Identify technological options
2. Identify objectives and indicators
3. Quantify indicators
4. Quantify preferences, i.e., preference weights
5. Find the optimal technological option

Step 1: Identify technological options

Technological options, i.e., animal welfare scenarios (AW scenarios), are the choices that have to be ranked in order to come to a decision. An AW scenario defines a production system with a specific attention to AW. An AW scenario requires major or minor changes in the production system compared to the point of reference, i.e., the legal AW standards and, in turn, provides a higher level of animal welfare than the point of reference. A production system is described in terms of technical and economic parameters. Some of the external and internal forces described in "The Context of On-Farm Decisions Regarding Animal Welfare" section are also specified in an AW scenario, these forces influence the technical and economic parameters of production. Consumer demand (external force) may affect producer price (economic parameter) or the skill level of the farmer (internal force) may affect mortality rate (technical parameter) through management routine.

Step 2: Identify objectives, attributes, and indicators

Objectives are the considerations that influence the desirability of a choice option. Attributes describe a detailed objective. Indicators are the variables used to describe the technological options in terms of their performance in contributing to each attribute. There are a number of essential criteria to be fulfilled when identifying objectives and their attributes (Clemen and Reilly, 2001). The set of objectives should be complete, at the same time as small as possible, decomposable, and non-redundant. Attribute scale must be operational. Likewise, selection criteria for indicators are often considered. de Boer and Cornelissen (2002) defined sustain-ability indicators based on four selection criteria to assess sustainability of different egg production systems. Accordingly, the four selection criteria are (1) indicators should be measurable (2) indicators discriminate among alternatives, (3) information should be available to quantify the possible indicators, (4) and a target value, based on political goals, scientific knowledge, or expert judgement, can be determined for the possible indicators.

Step 3: Quantify indicators

A stochastic economic simulation model provides quantitative information on choice options, i.e., AW scenarios (in terms of possible indicators, such as net farm income, total labor used, and volume of production, from Table 2.2). The economic model consists of two components, i.e., economic and technical. The economic component includes inputs related to e.g., value and costs of land and animals, and sale prices. The technical component concerns inputs, such as feed conversion ratio and mortality which usually depend on management variables, such as type of breed and space allowance. Partial or whole-farm budget models are suitable to simulate the risk and the financial and technical performance of different AW scenarios over a longer planning horizon (Lien, 2003; Verspecht et al., 2011). AW decisions are surrounded by considerable uncertainty. The effect of uncertainty can be incorporated into the analysis by using Monte Carlo simulation (Hardaker et al., 2004). Farm level analysis is usually carried out using a static model (Weersink et al., 2002). However, the analysis of AW decisions requires a more dynamic representation of the decision-making because AW decisions usually concern a longer time horizon, i.e., 10–15 years and concepts that can be adopted in a step-wise manner requiring dynamic investments.

While the economic simulation model can provide information on a range of possible indicators, it is not applicable to quantify the level of animal welfare associated with different systems modeled. Various methods are available to assess on-farm animal welfare. During the assessment of AW, animal-based parameters are getting more attention (e.g., Welfare Quality Assessment protocols), because they actually reflect the condition of the animal, however at herd level. Main disadvantages of animal based parameters are that recording is difficult and requires considerable amount of time and money (Mollenhorst et al., 2005). While assessment using environment-based measures, such as animal needs index, is easy and demand less resources. Although it can be argued that they do not measure actual animal welfare, they can show clear differences in AW between housing systems (Mollenhorst et al., 2005). Using these welfare assessment systems as a basis in expert consultations, different production systems can be evaluated in terms of AW.

Step 4: Quantify preferences

To address the trade-off between the financial and non-financial goals, we need to have an evaluation of different AW scenarios in terms of farmers' objectives and preferences. Preference weights reflect the importance of each objective of the farmer. During the elicitation, the aim is to gather information on the basic preferences between attributes and attribute trade-offs. Attributes that are considered in the analysis describe an AW scenario, such as profitability, level of AW, labor requirement and income risk. The analysis is carried out on a pre-selected farmer panel which represents the main types of farmers that differ in their attitude and preferences. The analysis focuses on groups of farmers rather than on individual farmers because the operationalization of this step (and also later steps) at an individual farmer level is complex and laborious.

Stated preference techniques are developed to elicit preferences directly based on hypothetical, rather than actual, scenarios. Since AW scenarios that are subject to the analysis represent several not yet existing options stated preference techniques are suitable for our purpose. These techniques are commonly criticized because of the fact that actual behavior is not observed and thus they generally fail to take into account certain types of real market constraints (Louviere et al., 2000). However, stated preference techniques provide the only viable alternative to measure a wider set of values, such as moral and personal values. They are suitable to consider an array of choices that are fundamentally different than existing ones, as well as gain information about attribute trade-offs.

For preference elicitation, conjoint analysis is a widely used market research tool (Green and Srinivasan, 1978; Gustafsson et al., 2000). Conjoint analysis is a decompositional method where attributes are evaluated as combinations. It has been used to evaluate products or services in terms of their attributes and to rank alternatives (Ryan and Farrar, 2000; Kim et al., 2009; Lohrke et al., 2009). The importance of attributes relative to the overall utility and to each other can be established by using conjoint analysis (Stott et al., 2005). Conjoint analysis is preferred when there are only a few attributes. However, when a large number of attributes are considered the combination of self-explicated and conjoint tasks clearly have some benefits. Adaptive conjoint analysis combines aspect of compositional and decompositional approaches which allows to investigate many attributes without asking respondents to deal with too much information at one time (Meuwissen and van der Lans, 2005).

Step 5: Find the optimal technological option

Having the system parameters, financial consequences calculated and preference weights elicited (i.e., outputs from simulation and preference elicitation) a multi-objective optimization model is to be built. The most widely used methods in the agricultural field include goal programming, multi-objective programming and compromise programming (Romero et al., 1987; De Koeijer et al., 1995; Wallace and Moss, 2002; Acs, 2006).

Illustration for the Empirical Implementation of the Conceptual Approach

In this section, the aim is to demonstrate the usability of the conceptual approach in scientific analysis. Therefore, a simple numerical application of a multi-objective programming model is presented. Although the illustration is based on fictive numbers, in essence it reflects the underlying decision problem. Suppose, the farmer has two objectives, i.e., Z_1: maximization of gross margin (GM) and Z_2: maximization of the level of on-farm AW. There are three decision variables: x_1, x_2, and x_3, representing three different animal production systems the farmer is offered to choose from. Table 2.3 shows the contribution of production systems x_1, x_2, and x_3, to the gross margin (expressed in €/year) and to animal welfare (expressed as an aggregated index on farm level).

Table 2.3 Contribution of the production systems to the objectives

	Production system with low AW standards (x_1)	Production system with medium AW standards (x_2)	Production system with high AW standards (x_3)
Gross margin *(in €/year)*	12,000	7,500	5,000
Level of AW *(aggregated index on farm level)*	10	30	50

Hence, the structure of the multi-objective decision problem is:

$$Max\ U(Z) = w_1 * Z_1 + w_2 * Z_2$$

subject to

$$Z_1 = 12{,}000x_1 + 7{,}500x_2 + 5{,}000x_3$$

$$Z_2 = 10x_1 + 30x_2 + 50x_3$$

$$x_1 = \begin{cases} 1, if\ production\ system\ with\ low\ AW\ standards\ is\ chosen \\ 0, if\ otherwise \end{cases}$$

$$x_2 = \begin{cases} 1, if\ production\ system\ with\ medium\ AW\ standards\ is\ chosen \\ 0, if\ otherwise \end{cases}$$

$$x_3 = \begin{cases} 1, if\ production\ system\ with\ high\ AW\ standards\ is\ chosen \\ 0, if\ otherwise \end{cases}$$

$$x_1 + x_2 + x_3 = 1 \qquad \textbf{2.1}$$

$$x_1, x_2, x_3 \in \{0, 1\}$$

The decision problem is subject to one constraint, i.e., only one system can be chosen (equation 2.1.). It is assumed that the farmer maximizes a linear additive utility function [*U(Z)*]. For the sake of illustration, we assume two groups of farmers that differ in their preferences. Group 1 represents farmers who are strictly profit oriented, and group 2 represents farmers focused on improving AW. In other words, group 1 maximizes gross margin and is neutral about the level of AW, while group 2 maximizes the level of AW and is neutral about the gross margin. Hence, the weights (w_1, w_2) for group 1 are (1, 0) and (0, 1) for group 2. Solving the problem according to Z_1 (i.e., $w_1 = 1$ and $w_2 = 0$), gives point A (1, 0, 0) in the decision space (Figure 2.2). Optimizing the problem according to the Z_2 (i.e., $w_1 = 0$ and $w_2 = 1$) gives point C (0, 0, 1). The objective values presented, i.e., A′B′C′, are plotted in the objective space in Figure 2.3.

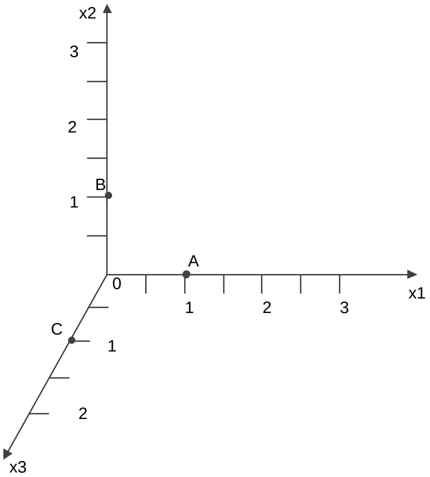

Figure 2.2 Graphical illustration of the initial solution in the decision space

Linear preferences

The best solution for the profit-oriented farmers is given by point A′, where the gross margin is maximized Figure 2.3. Graphically, the solution can be determined by drawing indifference curves which represent distinct level of preference (Varian, 2010). The slope of indifference curve is given by the relative preferences (-*w1*/*w2*). Based on the preferences in this example, for group 1 vertical indifference curves can be drawn. Assuming monotonic preferences, moving the indifference curves to the right within the feasible area, the solution with the highest utility can be found (Varian, 2010). Similarly, indifference curves for group 2 are moved upwards, to give the feasible solution (that maximizes utility). The welfare farmers, in turn, end up at point C′ which maximizes the level of AW. This is a special case, where farmers only care about one of the objectives and neutral about the other one. It illustrates the maximal values of the objectives cannot be obtained simultaneously. However, it is likely that farmers take into account both objectives to a certain extent and that trade-off exists between objectives. The line segment A′C′ represents efficient trade-offs between two objectives. To take into account these trade-offs, a necessary assumption is that any combination of A′ and C′ can be chosen (i.e., not a discrete choice problem). Now, the question is which preference structures imply the choice of one of these trade-offs. This question can be answered by examining all the possible combination of the weights. Graphically, the following ranges of relative preferences that results in different solutions can be found

1. $-\infty \leq - w1/w2 < - 1/175$, the solution is C’
2. $w1/w2 = - 1/175$, the solution can be any of the points of line segment A’C’
3. $1/175 < - w1/w2 \leq$ undefined , the solution is A’.

It shows that solutions on the line segment A′C′ are only considered if the ratio of $-w1/w2$ equals to the slope of A′C′ line segment, i.e., -1/175.

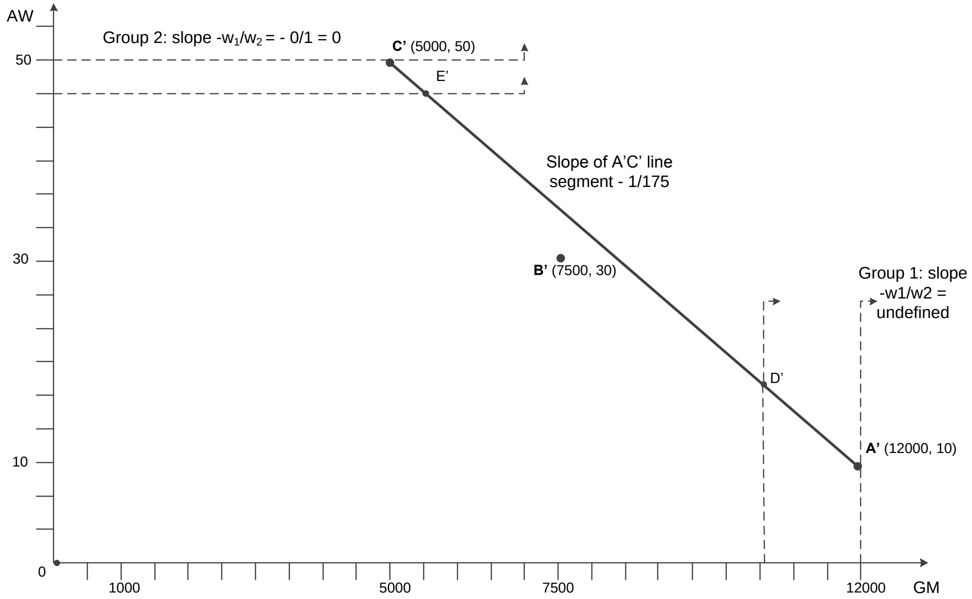

Figure 2.3 Graphical illustration of solutions in the objective space. Dashed lines indicate indifference curves

Non-linear preferences

So far, we assumed linear preferences and a linear utility function. However, farmers usually exhibit non-linear preferences resulting in utility functions with diminishing marginal rate of substitution (MRS). This means that the amount of gross margin that a farmer is willing to give up for an additional unit of AW increases as the amount of gross margin increases (Varian, 2010). In this case, the shape of the indifference curves that reflect the farmer's preference structure are similar to those depicted in Figure 2.4.

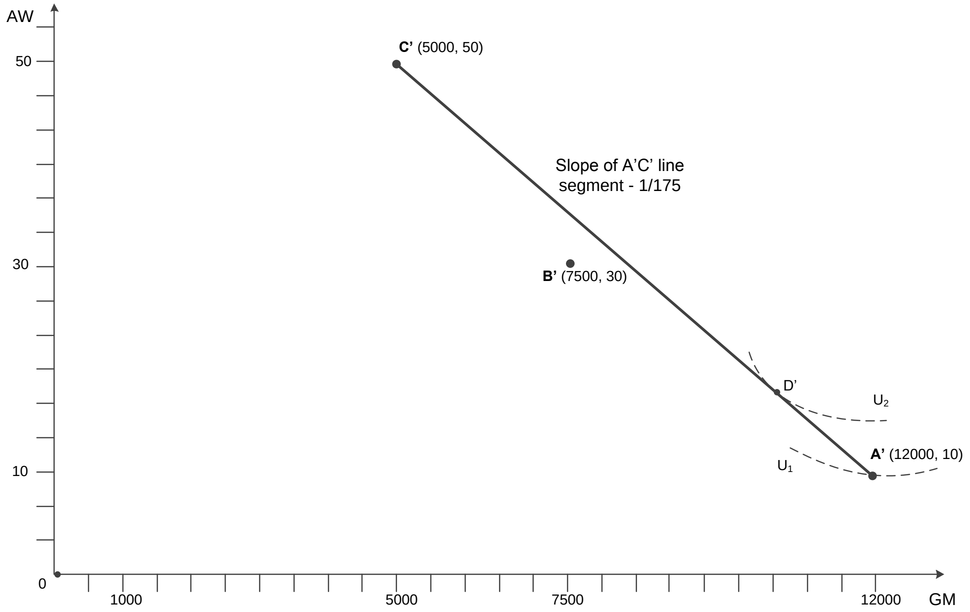

Figure 2.4 Optimal choices assuming non-linear preferences. A′ optimal choice (lying on indifference curve U1) if only discrete choices are offered; D' optimal choice (lying on indifference curve U2) if combination of A' and C' can be made

Assuming that the farmer is offered the opportunity to move to any point on the line segment A′C′ with slope -1/175 and diminishing MRS, then it is theoretically reasonable that a farmer accepts a solution from line segment A′C′. In this case, the optimal solution is D′, because D′ lies on the indifference curve that maximizes utility. However, in practice, farmers cannot necessarily choose the option with the highest utility, because they are offered a limited set of options. If farmers have to choose either A′ or C′, option A′ would be chosen because option A′ gives higher utility than option C′ does.

Conclusions

Understanding of the farmers' decision-making (e.g., goals, trade-offs, and type of farmers), evaluating their preferences and gaining insight into the main factors and barriers determining farmers' AW decisions are crucial for the success of future market initiatives concerning AW. The objectives of the article were to develop a theoretical framework of farmers AW decisions that incorporates farmers' goals, use, and non-use values and to present an approach to empirically implement the theoretical framework. The multiple criteria decision making paradigm provides an appropriate framework for the analysis of farmers AW decisions. The farmer makes his decision considering a wide range of objectives. The objectives contribute to the farmer's overall utility and the choices are made to maximize his utility. Empirical implementation of a utility-based approach poses some challenges in empirical implementations. That is, finding a multi-attribute utility function that represents the preference system of the farmer and the trade-offs that he is willing to make is not an easy task. By the means of a multi-objective optimization model, the need for the explicit functional form for the farmer's utility is eliminated. The effect of external and internal constraints on farmers final choices is possible to incorporate in an optimization model.

To illustrate the practical applicability of the approach, an illustration is presented in ''Illustration for the Empirical Implementation of the Conceptual Approach'' section. The description of this approach was an initial step towards an improved quantitative modeling of on-farm AW decisions. The approach will be implemented and presented in further studies. The outcome of this analysis could be relevant during the development of new AW concepts that aims to supply products that comply with above-legal AW standards for middle-market segments. In other words, the analysis can provide insights into the likelihood of whether farmers would join a specific AW concept, and can reveal technical, economic and risk barriers that may hamper farmers' participation in AW concepts.

Finally, although the approach presented has been developed with a particular focus on AW, its generic application needs to be emphasized as well. That is, this approach could be applied to other cases where a trade-off is made between financial and non-financial aspects, i.e., organic farming, or in the analysis of corporate social responsibility.

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References

Ács, S. (2006). Bio-economic modelling of conversion from conventional to organic farming. Ph.D. thesis, Wageningen University, the Netherlands.

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50: 179–211.

Ajzen, I., Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.

Ajzen, I., Fishbein, M. (2000). Attitudes and the attitude-behavior relation: Reasoned and automatic processes. European Review of Social Psychology, 11:1–33. DOI: 10.1080/14792779943000116.

Ajzen, I., Fishbein, M. (2005). The influence of attitudes on behavior. In D. Albarracín, B. T. Johnson, M. P. Zanna (Eds.), The handbook of attitudes. Lawrence Erlbaum Associates, Mahwah, NJ..

Ajzen, I.,Fishbein, M. (2008). Scaling and testing multiplicative combinations in the expectancy-value model of attitudes. Journal of Applied Social Psychology, 38:2222–2247.

Anonymous 2. (2004). Houden van Hennen. Available at http://www.duurzameveehouderij.wur.nl/UK/. Accessed 20-09-2011.

Anonymous 4. (2004). Welfare quality: Science and society improving animal welfare in the food quality chain. Available at http://www.welfarequality.net. Accessed 21-09-2011.

Anonymous 1. (2008). EconWelfare, good animal welfare in a socio-economic context: Project to promote insight on the impact for the animal, the production chain and European society of upgrading animal welfare standards.

Anonymous 3. (2010). Varkansen. http://www.duurzameveehouderij.wur.nl/UK/. Accessed 20-09-2011.

Appleby, M.C. (2003). The European ban on conventional cages for laying hens: History and prospects. Journal of Applied Animal Welfare Science, 6:103–121.

Aramyan, L., Ondersteijn, C., van Kooten, O., Oude Lansink, A.G.J.M., Wijnands, J.O., Huirne, R. (2006). Performance indicators in agri-food production chains. In C. J. M. Ondersteijn, J. H. M. Wijnands, R. B. M. Huirne, & O. van Kooten (Eds.), Quantifying the agri-food supply chain (pp. 49–66). the Netherlands: Springer.

Austin, E.J., Deary, I.J., Edwards-Jones, G., Arey, D. (2005). Attitudes to farm animal welfare. Journal of Individual Differences, 26:107–120. DOI: 10.1027/1614-0001.26.3.107.

Austin, E.J., Deary, I.J., Gibson, G.J., McGregor, M.J., Dent, J.B. (1996). Attitudes and values of Scottish farmers: ''Yeoman'' and ''entrepreneur'' as factors, not distinct types. Rural Sociology, 61:464–474.

Beedell, J.D.C., Rehman, T. (1999). Explaining farmers' conservation behaviour: Why do farmers behave the way they do? Journal of Environmental Management, 57:165–176.

Bennett, R.M. (1996). People's willingness to pay for farm animal welfare. Animal Welfare, 5:3–11.

Bergevoet, R.H.M. (2005). Entrepreneurship of Dutch dairy farmers. Ph.D. thesis, Wageningen University, the Netherlands.

Bergevoet, R.H.M., Ondersteijn, C.J.M., Saatkamp, H.W., van Woerkum, C.M.J., Huirne, R. B. M. (2004). Entrepreneurial behaviour of Dutch dairy farmers under a milk quota system: Goals, objectives and attitudes. Agricultural Systems, 80:1–21. DOI: 10.1016/j.agsy.2003.05.001.

Bonafos, L., Simonin, D., Gavinelli, A. (2010). Animal welfare: European legislation and future perspectives. Journal of Veterinary Medical Education, 37: 26–29.

Bracke, M.B.M., Greef, K.H.D., Hopster, H. (2005). Qualitative stakeholder analysis for the development of sustainable monitoring systems for farm animal welfare. Journal of Agricultural and Environmental Ethics, 18:27–56. DOI: 10.1007/s10806-004-3085-2.

Capon, C. (2008). Understanding strategic management. Pearson Education Limited, London, UK.

Clemen, R.T., & Reilly, T. (2001). Making hard decisions with decision tools. Pacific Grove, CA:Duxbury.

Darnhofer, I., Schneeberger, W., & Freyer, B. (2005). Converting or not converting to organic farming in Austria: Farmer types and their rationale. Agriculture and Human Values, 22:39–52. DOI: 10. 1007/s10460-004-7229-9.

David, F.R. (2001). Strategic management: Concepts (8th ed.). Englewood Cliffs, Prentice Hall, Inc., NJ.

De Boer, I.J.M., & Cornelissen, A.M.G. (2002). A method using Sustainability indicators to compare conventional and animal-friendly egg production systems. Poultry Science, 81:173-181.

De Buck, A.J., van Rijn, I., Röling, N.G., Wossink, G.A.A. (2001). Farmers' reasons for changing or not changing to more sustainable practices: An exploratory study of arable farming in the Netherlands. The Journal of Agricultural Education and Extension, 7:153–166.

De Koeijer, T.J., Renkema, J. A., Vanmensvoort, J.J.M. (1995). Environmental-economic analysis of mixed crop-livestock farming. Agricultural Systems, 48:515–530.

De Lauwere, C.C. (2005). The role of agricultural entrepreneurship in Dutch agriculture of today. Agricultural Economics, 33:229–238.

De Wit, B., Meyer, R. (2004). Strategy: Process, content, context (3rd ed.). Thomson Learning Stamford, CT.

Den Ouden, M., Huirne, R.B.M., Dijkhuizen, A.A., van Beek, P. (1997). Economic optimization of pork production-marketing chains 2. Modelling outcome. Livestock Production Science, 48:39–50.

Dyer, J.S., Fishburn, P.C., Steuer, R.E., Wallenius, J., Zionts, S. (1992). Multiple criteria decision making, multiattribute utility theory: The next ten years. Management Science, 38:645–654.

Eagly, A.H., Chaiken, S. (1993). The psychology of attitudes. Harcourt Brace Jovanovich, Inc., Fort Worth, TX.

Edwards-Jones, G., Deary, I., Willock, J. (1998). Incorporating psychological variables in models of farmer behaviour: Does it make for better predictions? Etudes et Recherches sur les Systèmes Agraires et le Développement., 31:153–173.

European Commission. (2007). Attitudes of EU citizens towards animal welfare.

Farmar-Bowers, Q., Lane, R. (2009). Understanding farmers' strategic decision-making processes and the implications for biodiversity conservation policy. Journal of Environmental Management, 90:1135–1144. DOI: 10.1016/j.jenvman.2008.05.002.

Fishbein, M., Ajzen, I. (1975). Belief, attitude, intention, and behavior: An introduction to theory and research. Addison-Wesley, Reading, MA.

Fishbein, M., Triandis, H.C., Kanfer, F.H., Becker, M., Middlestadt, S.E., Eichler, A. (2001). Factors influencing behavior and behavior change. In A. Baum, T. A. Revenson, & J. E. Singer (Eds.), Handbook of health psychology. Lawrence Erlbaum Associates, Mahwah, NJ.

Fredrickson, J.W. (1984). The comprehensiveness of strategic decision processes: Extension, observations, future directions. The Academy of Management Journal, 27:445–466.

Garner, M.G., Hamilton, S.A. (2011). Principles of epidemiological modelling. Revue Scientifique Et Technique-Office International Des Epizooties, 30:407–416.

Gasson, R. (1973). Goals and values of farmers. Journal of Agricultural Economics, 24:521–542.

Ghadim, A.K.A., Pannell, D.J. (1999). A conceptual framework of adoption of an agricultural innovation. Agricultural Economics, 21:145–154.

Gorsuch, R. L., Ortberg, J. (1983). Moral obligation and attitudes—their relation to behavioral intentions. Journal of Personality and Social Psychology, 44:1025–1028.

Green, P. E., Srinivasan, V. (1978). Conjoint analysis in consumer research: Issues and outlook. Journal of Consumer Research, 5:103–123.

Gustafsson, A., Herrmann, A., Huber, F. (2000). Conjoint analysis as an instrument of market research practice. In A. Gustafsson, A. Herrmann, & F. Huber (Eds.), Conjoint measurement: Methods and applications (pp. 5–45). Springer, Berlin.

Hall, B.H., Khan, B. (2003). Adoption of new technology. Working paper no. E03-330. Department of Economics, UC Berkeley.

Hardaker, J. B., Huirne, R.B.M., Anderson, J. R., Lien, G. (2004). Coping with risk in agriculture (2nd ed.). CABI, Wallingford.

Harland, P., Staats, H., Wilke, H.A.M. (1999). Explaining proenvironmental intention and behavior by personal norms and the theory of planned behavior. Journal of Applied Social Psychology, 29:2505–2528.

Harper, G.C., Makatouni, A. (2002). Consumer perception of organic food production and farm animal welfare. British Food Journal, 104:287–299.

Hubbard, C., Bourlakis, M., Garrod, G. (2007). Pig in the middle: Farmers and the delivery of farm animal welfare standards. British Food Journal, 109:919–930. DOI: 10.1108/ 00070700710835723.

Hudson, D. (2010). Discussion: The economics of animal welfare. Journal of Agricultural and Applied Economics, 42:453–455.

Kim, G., Kim, A., Sohn, S. (2009). Conjoint analysis for luxury brand outlet malls in Korea with consideration of customer lifetime value. Expert Systems with Applications, 36:922–932. DOI: 10. 1016/j.eswa.2007.10.004.

Kjærnes, U., Bock, B.B., Higgin, M., Roex, J. (2009). Farm animal welfare within the supply chain, regulation, agriculture and geography. Welfare quality reports no. 8.

Lagerkvist, C.J., Hansson, H., Hess, S., Hoffman, R. (2011). Provision of farm animal welfare: Integrating productivity and non-use values. Applied Economic Perspectives and Policy, 33:484–509. DOI: 10.1093/Aepp/Ppr037.

Lagerkvist, C.J., Hess, S. (2011). A meta-analysis of consumer willingness to pay for farm animal welfare. European Review of Agricultural Economics, 38:55–78. DOI: 10.1093/Erae/Jbq043.

Law, A.M. (2005). How to build valid and credible simulation models. In M. Kuhl, F. A. Steiger, & J. Joines (Eds.), Winter simulation conference 2005, Orlando, FL (pp. 24–32).

Law, A.M., Kelton, W.D. (1991). Simulation modeling and analysis (2nd ed.). McGrew-Hill Inc., New York, USA.

Lien, G. (2003). Assisting whole-farm decision-making through stochastic budgeting. Agricultural Systems, 76:399–413.

Lohrke, F.T., Holloway, B.B., Woolley, T.W. (2009). Conjoint analysis in entrepreneurship research: A review and research agenda. Organizational Research Methods, 13:16–30. DOI: 10.1177/ 1094428109341992.

Louviere, J.J., Hensher, D. A., Swait, J. D., Adamowicz, W. L. (2000). Stated choice methods: Analysis and application. Cambridge University Press, Cambridge.

Manstead, A.S.R. (2000). The role of moral norm in the attitude-behavior relation. In D. J. Terry & M. A. Hogg (Eds.), Attitudes, behavior, and social context: The role of norms and group membership (pp. 11–30). Lawrence Erlbaum Associates, Inc., NJ.

Meuwissen, M.P.M., van der Lans, I.A. (2005). Trade-offs between consumer concerns: An application for pork supply chains. Food Economics—Acta Agriculturae Scandinavica, Section C, 2:27–34. DOI:

10.1080/16507540510033442.

Mintzberg, H., Raisinghani, D., Theoret, A. (1976). The structure of unstructured decision-processes. Administrative Science Quarterly, 21:246–275.

Mollenhorst, H., Rodenburg, T.B., Bokkers, E.A.M., Koene, P., de Boer, I.J.M. (2005). On-farm assessment of laying hen welfare: A comparison of one environment-based and two animal-based methods. Applied Animal Behaviour Science, 90:277–291. DOI: 10.1016/j.applanim.2004.08.011.

Nocella, G., Hubbard, L., Scarpa, R. (2010). Farm animal welfare, consumer willingness to pay, and trust: Results of a cross-national survey. Applied Economic Perspectives and Policy, 32:75–297. DOI: 10.1093/aepp/ppp009.

Nuthall, P.L. (2010). Farm business management—the human factor. Wallingford, CAB International, Oxfordshire.

Ohlmer, B., Olson, K., Brehmer, B. (1998). Understanding farmers' decision making processes and improving managerial assistance. Agricultural Economics, 18: 273–290.

Olsen, J.V., Lund, M. (2011). The impact of socio-economic factors and incentives on farmers' investment behaviour. Food Economics—Acta Agriculturae Scandinavica, Section C, 8:173–185. DOI: 10.1080/16507541.2011.642501.

Oude Lansink, A.G.J.M., Verstegen, J.A.A.M., van den Hengel, J.J. (2001). Investment decision making in Dutch greenhouse horticulture. Netherlands Journal of Agricultural Science, 49:357–368.

Padel, S. (2001). Conversion to organic farming: A typical example of the diffusion of an innovation? Sociologia Ruralis, 41:40–61.

Pannell, D.J. (2003). Uncertainty and adoption of sustainable farming systems. In B. A. Babcock, R. W. Fraser, & J. N. Lekakis (Eds.), Risk management and the environment: Agriculture in perspective (pp. 67–81). Kluwer, Dordrecht.

Pietola, K.S., Oude Lansink, A.G.J.M. (2001). Farmer response to policies promoting organic farming technologies in Finland. European Review of Agricultural Economics, 28:1–15.

Qiu, Z. (2005). Using multi-criteria decision models to assess the economic and environmental impacts of farming decisions in an agricultural watershed. Review of Agricultural Economics, 27:229–244. DOI: 10.1111/j.1467-9353.2005.00223.x.

Rehman, T., Romero, C. (1993). The application of the MCDM paradigm to the management of agricultural systems—some basic considerations. Agricultural Systems, 41:239–255.

Romero, C., Amador, F., Barco, A. (1987). Multiple objectives in agricultural planning: A compromise programming application. American Journal of Agricultural Economics, 69:78–86.

Ryan, M., Farrar, S. (2000). Using conjoint analysis to elicit preferences for health care. BMJ, 320:1530–

1533. DOI: 10.1136/bmj.320.7248.1530.

Sargent, R. (2007). Verification and validation of simulation models. In S. G. Henderson, B. Biller, M. H. Hsieh, J. Shortle, J. D. Tew, & R. A. Barton (Eds.), Winter simulation conference 2007, Washington DC, (pp. 124–137).

Schoon, B., te Grotenhuis, R. (2000). Values of farmers, sustainability and agricultural policy. Journal of Agricultural and Environmental Ethics, 12:17–27.

Schwartz, S.H. (1968). Words, deeds, and the perception of consequences and responsibility in action situations. Journal of Personality and Social Psychology, 10:232–242.

Schwartz, S.H. (1977). Normative influences on altruism. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 10, pp. 221–279). Academic, New York.

Sørensen, J. T., Sandøe, P., Halberg, N. (2001). Animal welfare as one among several values to be considered at farm level: The idea of an ethical account for livestock farming. Acta Agriculturae Scandinavica Section A—Animal Science, 51:11–16.

Stott, A., Milne, C., Goddard, P., Waterhouse, A. (2005). Projected effect of alternative management strategies on profit and animal welfare in extensive sheep production systems in Great Britain. Livestock Production Science, 97:161–171. DOI: 10.1016/j.livprodsci.2005.04.002.

Tauson, R. (2005). Management and housing systems for layers—effects on welfare and production. Worlds Poultry Science Journal, 61:477–490. DOI: 10.1079/Wps200569.

Vanhonacker, F., Verbeke, W., van Poucke, E., Tuyttens, F.A.M. (2007). Segmentation based on consumers' perceived importance and attitude toward farm animal welfare. International Journal of Sociology of Agriculture and Food, 15:91–107.

Varian, H.R. (2010). Intermediate microeconomics (8th ed.). W.W. Norton Company, London.

Verhoog, H., Lund, V., Alrøe, H.F. (2004). Animal welfare, ethics and organic farming. In M. Vaarst, S. Roderick, Lund, V., Lockeretz, W. (Eds.), Animal health and welfare in organic agriculture. CAB International, London.

Verspecht, A., Vanhonacker, F., Verbeke, W., Zoons, J., van Huylenbroeck, G. (2011). Economic impact of decreasing stocking densities in broiler production in Belgium. Poultry Science, 90:1844–1851. DOI: 10.3382/ps.2010-01277.

Vosough-Ahmadi, B., Stott, A.W., Baxter, E.M., Lawrence, A., Edwards, S.A. (2011). Animal welfare and economic optimisation of farrowing systems. Animal Welfare, 20:57–67.

Wallace, M.T., Moss, J.E. (2002). Farmer decision-making with conflicting goals: A recursive strategic programming analysis. Journal of Agricultural Economics, 53:82–100.

Wallenius, J., Dyer, J. S., Fishburn, P. C., Steuer, R. E., Zionts, S., Deb, K. (2008). Multiple criteria decision making, multiattribute utility theory: Recent accomplishments and what lies ahead. Management Science, 54:1336–1349. DOI: 10.1287/mnsc.1070.0838.

Weersink, A., Jeffrey, S., Pannell, D. (2002). Farm-level modeling for bigger issues. Review of Agricultural Economics, 24:123–140.

Willock, J., Deary, I. J., McGregor, M.M., Sutherland, A., Edwards-Jones, G., Morgan, O., et al. (1999). Farmers' attitudes, objectives, behaviors, and personality traits: The Edinburgh study of decision making on farms. Journal of Vocational Behavior, 54:5–36.

Chapter 3

Elicitation of preferences of Dutch broiler and pig farmers to support decision making on animal welfare

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Abstract

Conjoint analysis was conducted to elicit Dutch broiler and fattening pig farmers' preferences about different characteristics of production systems, with a primary interest in farmers' intrinsic motivation towards animal welfare (AW). A cluster analysis was carried out to identify distinct groups of farmers with homogeneous preferences. The results showed that farmers preferred conventional practices and had negative preferences towards free-range systems. Two clusters of broiler farmers were distinguished. The 'Free-range focused' cluster evaluated a production system by focusing on a single aspect, the provision of free-range access, while the 'Multi-attribute focused' cluster included multiple attributes in their evaluation. In the case of fattening pig farmers, no clusters could be identified. Results showed that farmers do not have a strong intrinsic motivation to switch to a system with higher animal welfare standards. It is therefore likely that the level of on-farm AW will be determined by external and farm-specific factors, and that higher levels of AW will only be achieved if these factors are favorable for the adoption of these production systems.

Keywords: Decision analysis, Farming systems, Livestock, Technology adoption

Introduction

Given the current international economic and political environment, increasing public concerns about farm animal welfare (AW) are mostly addressed through market-based initiatives that achieve AW standards above the minimum legal requirements, rather than implementing stricter legislative standards in Europe (Vanhonacker and Verbeke, 2014). In the Netherlands, a middle-market segment has emerged that is positioned between conventional and organic products in terms of AW, and which supplies meat products that comply with AW standards above the minimum legal requirements (Gocsik et al., 2013). These market initiatives were generally developed to balance the different interests of stakeholders, citizens, and consumers (Verbeke, 2009). Hence, these initiatives are not always aligned with farmers' interests and preferences, even though their success depends on the participation of farmers. Therefore, knowledge about the preferences of farmers and the factors that determine participation in market initiatives is essential if new market initiatives are to be successful in achieving higher levels of on-farm AW.

The decision to adopt a new production system with higher levels of AW is affected by farmers' intrinsic motivation, and external and farm-specific factors and constraints (Padel, 2001; Edwards-Jones, 2006; Knowler and Bradshaw, 2007; Gocsik et al., 2014a). Intrinsic motivation concerns an individual's internal reasons for undertaking a particular action and appeals to a farmer's moral obligation. This paper focuses on farmers' intrinsic motivation to improve AW. Studies exploring farmers' intrinsic motivation to improve AW have tended to investigate farmers' attitudes about AW using qualitative interviews. Studies focusing on pig producers showed that AW was conceived mainly as biological health and functioning, and that producers preferred to keep pigs in a well-controlled environment that was properly managed (van Huik and Bock, 2007; Hubbard et al., 2007; Spooner et al., 2013). A recent study explored the attitude of Dutch pig farmers towards specific practices to reduce tail docking, as one of the important AW issues (Bracke et al., 2013). Results of the study suggest that farmers perceive stopping with the routine practice of tail docking as a very important risk factor for tail biting among pigs. Other studies explored farmers' motivation by identifying the cognitive determinants of farmers' decision-making using social-psychology theories, such as the Theory of Planned Behavior (de Lauwere et al., 2012; Hansson and Lagerkvist, 2014). Although the current literature provides a general view on farmers' perception of AW, these studies were mainly descriptive and did not provide quantitative information on the trade-offs between particular system characteristics. In addition, these studies did not address the context of the production systems and market initiatives in the Netherlands. Market initiatives and related production systems differ in the range of production system characteristics, and farmers' preferences about these different characteristics are likely to be different too. Hence, information on such trade-offs, particularly related to currently available production systems, can be useful in designing new market initiatives (Schoon and Te Grotenhuis, 2000; Gocsik et al., 2014a).

Broiler and fattening pig production are the two most important meat production sectors in the Netherlands in terms of quantity, with a production of 867,000 tons and 1,311,000 tons in 2013, respectively (PPE, 2014; PVV, 2014). Public concerns about AW are particularly strong in these sectors and several market initiatives with higher AW standards have been developed in the past decade. The aim of this study was to elicit Dutch broiler and fattening pig farmers' preferences about AW-related characteristics of production systems.

Materials and methods

Questionnaire

The survey for broiler and fattening pig farmers was administered using a paper and pencil questionnaire in a study group setting, and carried out in Dutch. Prior to the actual data collection, the questionnaire for broiler farmers was pre-tested, face-to-face, with a broiler farmer to check whether the questionnaire was understandable for the target group. The questionnaire for broiler farmers was revised based on his comments, and general comments about the structure of the questionnaire were also taken into account in revising the questionnaire for pig farmers. The resulting questionnaires for both sectors consisted of two distinct parts. The first part contained questions regarding the respondents' demographic and socio-economic characteristics. The second part contained a conjoint task to elicit farmer's preferences about production systems.

Sample

Data collection

Data were collected from October to December 2013 in the province of Noord-Brabant, which is the main area for broiler and pig production in the Netherlands. Broiler farmers and fattening pig farmers who participated in study groups were asked to participate in the survey. In total, 22 broiler farmers and 15 fattening pig farmers participated in the survey. The respondents represented approximately 12% of the broiler farmers and 1% of the fattening pig farmers in Noord-Brabant. A farmer organization operating in the Southern part of the Netherlands (ZLTO) assisted in approaching potential participants for the study, all of whom were members of farmer-initiated study groups. In the area of Noord-Brabant there are seven farmer-initiated study groups of broiler farmers and 30 study groups for pig farmers (however in the study groups for pig farmers not only fattening farmers are involved, but sow farmers and farmers with mixed farms). Three of the study groups of broiler farmers, and three of the 30 study groups of fattening pig farmers participated in the survey. The low response rate suggests that farmers were reluctant to provide information for this study. Farmers communicated that they were afraid that the information would be used to put pressure on farmers and that the results would be used against them.

During the study group meetings, participants were presented with a technical explanation about the questionnaire, with an introduction to the survey and explanation of the tasks included. Members of two of the three participating broiler study groups filled in the questionnaire individually at her/his own speed during the meeting. However, in the case of the third broiler study group and all the fattening pig study groups, filling in the questionnaire during the meeting was not feasible due to time constraints. Hence, participants were given the technical explanation and they were asked to fill the questionnaire in at home and to return the completed questionnaire within one week's time.

Demographic and socio-economic characteristics

Respondents for the survey of broiler production systems varied in age between 30 and 67 years (M[3] = 46.4, SD[4] = 8.4). Ninety-six percent of the respondents were male. The majority of respondents (69%) had worked for more than ten years as a self-employed farmer. Farming was the major source of family income for 86% of the respondents. Ninety-six percent of the respondents operated a conventional farm system, 76% of which had more than 90,000 animal places in the farm. The majority of the farmers (75%) had invested in farm expansions in the last ten years. Twenty-three percent of respondents produced for the domestic market only, 13% produced for the international market only, and 64% percent produced for both domestic and international markets.

Regarding the survey of fattening pig production systems, all 15 respondents were male with an age ranging from 31 to 61 years (M = 46.43, SD = 8.56). Respondents had many years of experience in farming as self-employed farmers (M = 23.69, SD =11.07). Farming was the main source of income for the majority of respondents. All respondents had conventional production systems, although small differences (e.g. providing natural enrichment material) compared to

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[3] M = mean

[4] SD = standard deviation

the conventional system defined in this study were indicated by some of the respondents. The sample mostly included medium-sized (1,001-2,000 animal places) and large-sized farms (more than 2,000 animal places). The majority of respondents had expanded their farms in the last ten years. About 70% of the respondents produced for the domestic market only, while 30% of the respondents indicated that they produced for both domestic and international market. For more details on the demographic and socio-economic characteristics, please see Table 3A.1 in Appendix 3A.

Conjoint Design

Model

The preferences of broiler and fattening pig farmers for different aspects of production systems were studied conjoint analysis. Conjoint analysis is a multivariate technique used to elicit individual preferences about multi-attribute products or services. The multi-attribute conjoint model assumes that individuals choose a product or a service based on its characteristics, or attributes (Hair et al., 2009). The decision to convert to an alternative production system was considered using the multi-attribute utility framework. The overall utility of a production system can be expressed as the sum of utilities for its attributes:

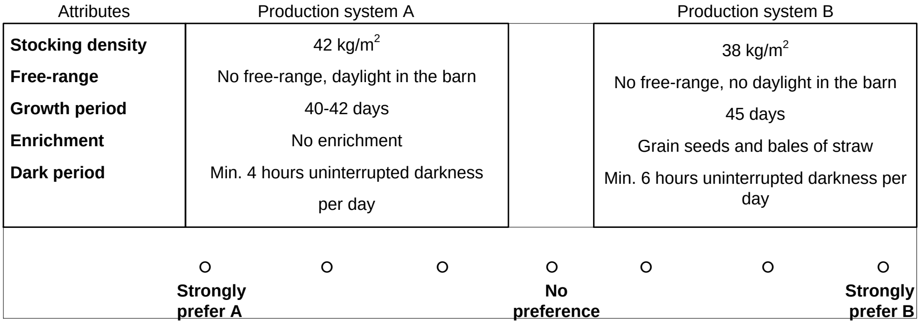
$$U = u_{i1} + u_{i2} + u_{i3} + \ldots + u_{in}, \qquad \textbf{3.1}$$

where U is the utility of a production system and u_{ij} is the utility of level i for attribute j, with (j=1 to n) and (i=1 to m_j), where m_j is the number of levels of attribute j.

Experimental design

The selection of attributes and levels was based on the broiler and fattening production systems currently present in the Netherlands (Gocsik et al., 2013; Gocsik et al., 2014b), with the exclusion of organic systems. Organic systems were excluded because studies have showed that a fundamental difference exists between conventional and organic farmers in terms of their attitude toward AW (van Huik and Bock, 2007; Hansson and Lagerkvist, 2014). Moreover, the organic meat sector is relatively small, with a small number of farmers, and targets a specific niche segment of consumers (EZ, 2013). In the case of broiler production systems, five attributes, each with two to four levels, were selected. Seven attributes, each with two to four levels, were selected for fattening pig production systems (Table 3.1). Hypothetical production systems (technically feasible though) were constructed by combining selected levels of each attribute using all attributes simultaneously (Hair et al., 2009). In the explanation of the survey during the data collection process, it was stressed that participants were to ignore the monetary consequences of adopting a production system, as the study focused on farmers' intrinsic motivations only.

Following Johnson (1987), the conjoint task consisted of a series of graded pairwise comparisons using full profiles (Hair et al., 2009). Respondents were asked to indicate to what extent they preferred one option to another, i.e., one production system (production system A) to the other (production system B) (Figure 3.1).



Attributes	Production system A		Production system B
Stocking density **Free-range** **Growth period** **Enrichment** **Dark period**	42 kg/m^2 No free-range, daylight in the barn 40-42 days No enrichment Min. 4 hours uninterrupted darkness per day		38 kg/m^2 No free-range, no daylight in the barn 45 days Grain seeds and bales of straw Min. 6 hours uninterrupted darkness per day

○ ○ ○ ○ ○ ○ ○

Strongly prefer A **No preference** **Strongly prefer B**

Figure 3.1 An example of a pairwise comparison task for broiler production systems

A seven-point Likert-scale ranging from -3 (*Strongly prefer A)* to 3 (*Strongly prefer B)* was used. Some combinations of the levels for different attributes were technically infeasible. These infeasible combinations were excluded from the pairwise comparison tasks, to ensure a valid estimation process and to facilitate the perceived credibility of the tasks among the respondents. Table 3.2 shows the technically infeasible combinations for broiler production systems. For fattening pig production systems, two technically infeasible combinations were identified. These were: indoor space of 0.7 m^2 with no free-range, no daylight in the barn and indoor space of 0.7 m^2 with no free-range, daylight in the barn. To avoid these infeasible combinations, a non-orthogonal fractional factorial main effects design combined with a cyclic design was generated using an exchange algorithm, which optimized D-efficiency. This algorithm was written in the R programming environment (R_Development_Core_Team, 2010). A description of the exchange algorithm is provided in Appendix 3B. To identify an appropriate design, D-optimality was chosen as the measure of design efficiency. A design with a D-efficiency of at least 90% relative to the orthogonal fractional factorial design is considered as

Table 3.1 Attributes and levels for broiler and fattening pig systems

Broiler		Fattening pig	
Attributes	Attribute levels	Attributes	Attribute levels
Stocking density	1) 42 kg/m^2	Indoor space	1) 0.7 m^2/fattening pig
	2) 38 kg/m^2		2) 0.8 m^2/fattening pig
	3) 31 kg/m^2		3) 0.9 m^2/fattening pig
	4) 27.5 kg/m^2		4) 1.0 m^2/fattening pig
Free-range	1) No free-range, no daylight in the barn	Free-range	1) No free-range, no daylight in the barn
	2) No free-range, daylight in the barn		2) No free-range, daylight in the barn
	3) Covered veranda 12x12 cm/chicken		3) 0.7 m^2/fattening pig free-range
	4) Outdoor access 1m^2/chicken		4) 1.0 m^2/fattening pig free-range
Growth period	1) 40-42 days	Bedding	1) Concrete floor with small amount of litter
	2) 45 days		2) Straw or sawdust (5-10 cm)
	3) 56 days		
	4) 63 days	Group size	1) 8-20 fattening pigs per group
			2) 8-30 fattening pigs per group
Enrichment	1) No enrichment		3) >40 fattening pigs per group
	2) Grain seeds and bales of straw		
		Enrichment materials	1) Metal chain with ball
Day-night rhythm	1) Unnatural, min. 4 h of uninterrupted darkness/day		2) Wood, sturdy rope, straw
	2) Natural, min. 6 h of uninterrupted darkness/day		3) Straw, roughage
	3) Natural, min. 8 h of uninterrupted darkness/day		
		Castration	1) Castration allowed
			2) Castration not allowed
		Tail docking	1) Tail docking allowed
			2) Tail docking not allowed

good (SAS Institute). The selected designs had D-efficiencies of 90.22% and 94.99% for broiler systems and fattening pig systems, respectively. The final design included a *calibration set* of 25pairwise comparison tasks for broiler farmers and 16 pairwise comparison tasks for fattening pig farmers. Each task consisted of a comparison of two production systems described on the basis of the specified attributes with different levels. To assess the internal validity of the utility estimates based on the calibration profiles, a set of four binary choice tasks was included as a *validation set* for both broiler and fattening pig farmers. These validation profiles were not used in the estimation step. Two of the validation profiles were randomly selected from the calibration set. The other two were chosen to represent current production systems.

Table 3.2 Feasible and infeasible combinations of levels for the relevant attributes of a broiler production system

	Stocking density (kg/m²)			
	42	38	31	27.5
Growth period (days)				
40-42	+	+	-	-
45	+	+	+	+
56	-	+	+	+
63	-	+	+	+
Free-range				
No free-range, no daylight in the barn	+	+	+	+
No free-range, daylight in the barn	+	+	+	+
Covered veranda 12x12 cm/chicken	-	+	+	+
Outdoor access 1 m²/chicken	-	+	+	+

‘+’: feasible combinations; ‘-': infeasible combinations

Data Analysis

Relative importance of the different production system attributes

Part-worths were estimated in SPSS using the method of ordinary least-squares regression at an individual respondent level, with graded pairwise comparisons as the dependent variable. A set of dummy variables was constructed for both the right-hand side and left-hand side profiles of the pairwise comparison tasks. The graded pairwise comparison ratings were regressed on the difference scores of these two sets of dummy variables. A regression model with no intercept was estimated because the dependent variable had a baseline of zero (i.e., no preference to any of the two given profiles). In the estimation of part-worths, the part-worth of one level within each attribute was arbitrarily set to zero to represent the reference level, and the remaining levels were estimated as deviations from the reference level. The reference level for each attribute was the level associated with the conventional system. To characterize the relative importance of each attribute, the difference between the best and worst level of one attribute was divided by the sum of the differences between the best and worst level of all the attributes (Hair et al., 2009). Respondents with a R^2, which represents a Tucker's coefficient of concordance (Zegers and Ten Berge, 1985), lower than 0.7 were excluded from further analysis, because the model was judged as unable to make good predictions for these respondents.

Predictive accuracy of individual models

Holdout validation was used to evaluate the internal predictive validity of the individual models. Hit rate validation (Kuhfeld, 2006) was used to examine how well the model predicted the holdout observations. Hit rates were expressed as the proportion of cases that were predicted correctly. Part-worths, estimated form the calibration set, were used to predict the utility obtained from the validation profile. Hit rates were corrected for non-response. If a model had a hit rate lower than or equal to 50%, the respondent was excluded from subsequent analysis. However, to allow for some margin of error, if the holdout task was judged as difficult to predict the respondent was retained in subsequent analysis. The holdout task was judged as difficult to predict if the difference between the utilities of the two alternatives was less than or equal to 0.2.

Cluster analysis

The estimated part-worths were used to investigate whether there were homogeneous groups of farmers with similar preferences. For this purpose, the 'clusterboot' procedure (R-package FPC) was used (Hennig, 2014). The 'clusterboot' procedure is an integrated function that computes the clustering and also assesses the cluster-wise stability (Hennig, 2006; Hennig, 2014). Clusters were found by the K-means clustering method. This method requires establishing the number of clusters *a priori*. Given the small sample size, cluster solutions from two clusters to five clusters were assessed. To assess cluster stability, the bootstrap method with 100 runs was applied and the computed Jaccard similarity value was used to assess the robustness of the cluster solution (Hennig, 2006; Hennig, 2014). Generally, a valid and stable cluster should yield a mean Jaccard similarity value of 0.75 or more (Hennig, 2014), and this was therefore the criterion used in this study.

External validation of results

The relatively small sample size reduces the extent to which the results can be generalized. To address this limitation, a workshop was organized with a panel of three experts specialized in poultry production and four experts specialized in pig production. These experts were farm advisors and veterinarians. Experts were asked to give an opinion on the representativeness of the main findings of the conjoint analysis, at both regional (the study area of Noord-Brabant and Limburg) and national levels. For this purpose, a questionnaire was developed, which contained statements describing the typical broiler and fattening pig farmer on the basis of the results of the survey. Experts were asked to indicate the percentage of the total number of broiler and fattening pig farmers in Noord-Brabant and in the Netherlands to which the statements were applicable. On the basis of the survey results, a 95% confidence interval was established for each statement. If the responses of the experts were within the confidence interval then the results of the survey were considered as generalizable (Witte and Witte, 2010).

Results

Part-worths and relative importance of attributes

In the case of broiler farmers, a total of 18 questionnaires were available for the conjoint analysis because four respondents (respondents 14, 15, 17, and 19) indicated no preference for nearly all of the two alternatives. Further, three respondents (respondents 3, 10, and 22) were eliminated from subsequent analysis after the individual models were estimated, as the R^2 of these individual models were lower than 0.7. Table 3.3 presents an overview of the estimated part-worths per attribute level for the respondents that were retained in the analysis. Levels with the highest part-worths are shown in bold and those with the lowest part-worths are shown in italic.

The relative importance of each attribute for each respondent is shown in Figure 3.2. Free-range was the most important attribute (M = 46.22%, SD = 17.03%), which indicates that the preference for a production system mostly depends on this attribute. Table 3.3 shows that the most preferred level was, in most cases, no free-range with no daylight in the barn. Access to free-range area (either covered veranda or outdoor access) was the least preferred. Growth period (M = 20.44%, SD = 9.64%) and stocking density (M = 19.22%, SD =12.01%) were, on average, evaluated as almost equally important, however slightly less variation was observed in the case of growth period. Regarding the length of the growth period, 40-42 days and 45 days were indicated as the most preferred levels. For stocking density, the majority of respondents attached the highest utility to a stocking density of 42 kg/m^2 or 38 kg/m^2. Day-night rhythm (M

Table 3.3 Part-worths per respondent for broiler farmers (levels with highest part-worths shown in bold; levels with lowest part-worths shown in italic)

Respondent	1	2	4	5	6	7	8	9	11	12	13	16	18	20	21
R^2	0.84	0.96	0.92	0.87	0.87	0.73	0.71	0.92	0.83	0.88	0.82	0.72	0.86	0.84	0.88
Hit rate (%)	100	75	50	75	75	100	75	100	75	100	100	100	100	100	75
Stocking density															
42 kg/m^2 [1]	**0**	*0*	*0*	0	**0**	*0*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*0*	*0*
38 kg/m^2	*-0.54*	0.14	**0.38**	-0.14	-0.25	0.86	-1.12	-0.31	*-0.96*	*-0.76*	*-0.29*	-1.66	-0.29	**0.33**	**1.32**
31 kg/m^2	-0.30	**0.26**	0.09	**0.13**	-0.36	**0.89**	-0.23	*-0.53*	-0.50	-0.29	-0.15	-1.45	*-0.45*	0.18	0.69
27.5 kg/m^2	-0.41	0.05	0.21	*-0.60*	*-0.56*	0.38	*-0.87*	-0.32	-1.41	-1.09	-0.01	*-1.73*	0.18	0.25	1.14
Free-range															
No free-range, no daylight in the barn[1]	**0**	**0**	**0**	**0**	**0**	**0**	0	**0**	**0**	0	**0**	**0**	**0**	**0**	**0**
No free-range, daylight in the barn	-0.41	-1.73	-1.78	-0.59	-1.52	-0.31	**0.37**	-0.31	-0.34	**0.46**	-1.00	-0.59	-1.62	-0.12	-0.10
Covered veranda 12x12 cm/chicken	-1.56	-1.92	*-3.36*	*-1.36*	*-2.82*	-2.36	0.11	*-1.84*	-0.69	-0.70	*-1.22*	*-0.74*	-2.64	-0.41	*-2.26*
Outdoor access 1 m^2/chicken	*-2.02*	*-2.02*	-3.26	-1.27	-2.76	*-2.53*	*-0.69*	*-1.84*	*-0.70*	*-1.56*	-1.17	-0.64	*-3.61*	*-1.08*	-1.95
Growth period															
40-42 days[1]	**0**	*0*	*0*	**0**	*0*	**0**	*0*	**0**	**0**	**0**	*0*	**0**	**0**	0	**0**
45 days	-0.25	**0.31**	**0.29**	0.02	0.33	-0.43	0.58	-0.97	-1.19	-0.27	0.19	-0.26	-0.49	*-0.15*	-0.93
56 days	-0.55	0.21	**0.29**	-0.49	0.12	-1.35	**0.61**	-1.15	-1.48	-0.86	0.02	**0.07**	-0.33	0.01	-0.96
63 days	*-0.97*	0.15	0.26	*-0.95*	**0.56**	*-1.54*	0.21	*-1.90*	*-1.89*	*-1.15*	**0.48**	*-0.44*	*-0.74*	**0.09**	*-1.03*
Enrichment															
No enrichment[1]	**0**	**0**	**0**	**0**	**0**	*0*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*0*	**0**
Whole grains and bales of straw	*-0.37*	*-0.04*	*-0.21*	*-0.71*	*-0.13*	**0.11**	*-0.10*	*-0.29*	*-0.21*	*-0.70*	*-0.13*	*-0.07*	*-0.28*	**0.23**	*-0.05*
Day night rhythm															
Unnatural, min.4 h of uninterrupted darkness/day[1]	0	0	*0*	0	0	*0*	*0*	*0*	*0*	*0*	**0**	*0*	0	0	0
Natural, min. 6 h of uninterrupted darkness/day	**0.09**	*-0.06*	**0.42**	*-0.07*	*-0.02*	0.18	**0.36**	**0.26**	0.37	**0.55**	-0.05	0.11	**0.27**	*-0.21*	**0.24**
Natural, min. 8 h of uninterrupted darkness/day	*-0.06*	**0.08**	0.29	**0.32**	**0.03**	**0.41**	0.13	0.03	**0.41**	0.03	*-0.32*	**0.25**	*-0.44*	**0.07**	*-0.16*

[1] Reference level

= 8.12%, SD = 3.10%) and enrichment (M = 5.99%, SD = 4.76%) had the lowest relative importance. The majority of respondents preferred no enrichment and a natural day-night rhythm with 6-8 hours of uninterrupted darkness per day. In the case of fattening pig farmers, one of the 15 respondents was excluded from the conjoint analysis (respondent 10) because this respondent indicated no preference for most of the two alternatives. Table 3.4 presents an overview of the part-worths per respondent for fattening pig farmers.

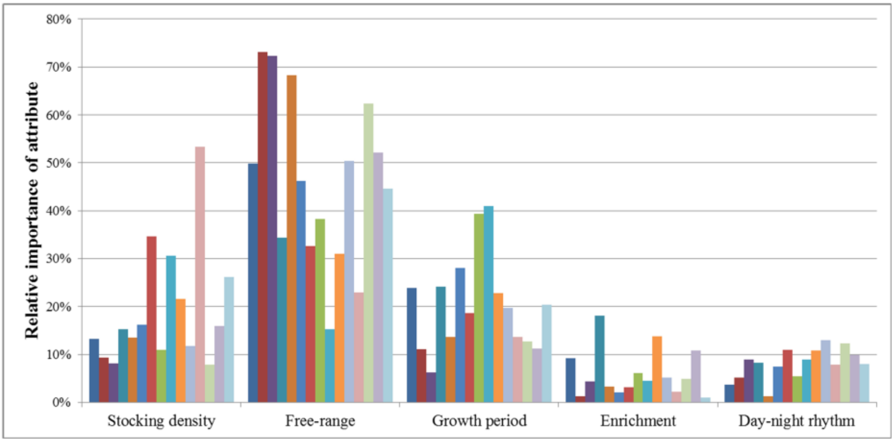


Figure 3.2 Distribution of relative importance per attribute for broiler farmers

The relative importance of the attributes for fattening pig farmers is presented in Figure 3.3. Figure 3.3 shows that free-range was the most important attribute (M = 33.84%, SD = 14.99%), followed by indoor space (M = 17.57%, SD = 12.15%). In the case of the free-range attribute, 'no free- range with daylight in the barn' was the most preferred level, and a free-range area of 1m^2/pig was, in the majority of cases, the least preferred level (Table 3.4). In the case of indoor space, some variation in the levels with the highest utility was observed; these levels were all less than or equal to 0.9 m^2 per animal. Equal importance was observed for the following attributes: castration (M =10.66%, SD = 18.86%), enrichment (M = 10.54%, SD = 5.13%), group size (M = 10.10%, SD = 5.94%), and bedding (M = 9.49%, SD = 5.06%). Regarding castration, levels with the highest utility varied among respondents. As for the provision of enrichment, respondents tended to prefer natural enrichment ('wood, sturdy rope, straw' and 'straw, roughage') to the metal chain with ball. Regarding the group size, no clear preference could be established at an aggregate level. Respondents preferred the concrete floor with a small amount of litter to straw or sawdust bedding. Tail docking was the least important attribute (M = 7.80%, SD = 6.89%), but scored only slightly lower than castration, enrichment, group size, and bedding. The majority of respondents preferred tail docking to no tail docking.

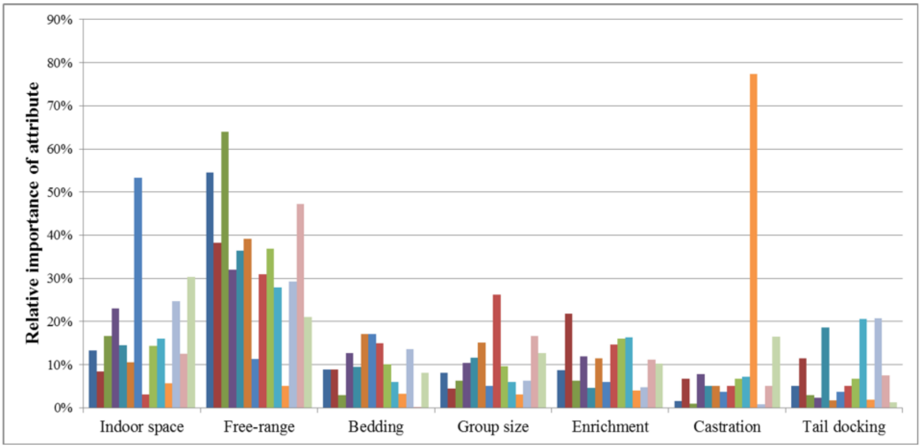


Figure 3.3 Distribution of relative importance per attribute for fattening pig farmers

Predictive accuracy of individual models

Given that there were two choices available in each holdout task, a random model could be expected to have a hit rate of 50%. In the case of broiler farmers, 14 of the 15 individual models had a higher hit rate than the random model (eight models with a hit rate of 100% and six models with a hit rate of 75%). The hit rates indicate that these individual models performed better than the random model, and that these individual models accurately predicted choice. One model (respondent 4) performed the same as the random model. Nevertheless, this model was retained in the further analysis, as the holdout tasks were considered to be difficult to predict correctly. This decision was based on the difference between the predicted overall utilities of the two alternatives for one holdout task. This difference was 0.16 (the utility of alternative 1 was -2.78; the utility of alternative 2 was -2.62) and therefore less than the criterion of 0.2. In the case of fattening pig farmers, 13 of the 14 individual models performed better than the random model (four models with a hit rate of 100% and ten models with a hit rate of 75%) and one model had a hit rate of 50% (respondent 15). In the case of this latter respondent, the differences between the utilities of the paired choice tasks were investigated. The difference between the utilities of the two alternatives was 0.73 for one task and 0.80 for the other task. Based on these differences, it was concluded that the tasks were not particularly difficult to predict and this respondent was therefore excluded from further analysis.

Table 3.4 Part-worths per respondent for fattening pig farmers (levels with highest part-worths shown in bold; levels with lowest part-worths shown in italic)

Respondent	1	2	3	4	5	6	7	8	9	11	12	13	14	15
R^2	0.97	0.99	0.95	0.95	0.96	0.93	0.98	0.83	0.97	0.99	1.00	0.91	0.86	0.97
Hit rate (%)	75	75	100	75	75	100	75	100	75	75	75	75	100	50
Indoor space														
0.7 m^2/fattening pig	0.24	0.21	**0.70**	*-2.06*	-0.46	**0.53**	*-1.84*	**0.04**	**0.31**	**0.55**	*-0.15*	-0.06	**1.00**	*-1.13*
0.8 m^2/fattening pig[1]	*0*	*0*	*0*	**0**	0	*0*	0	0	0	0	0	0	0	**0**
0.9 m^2/fattening pig	0.39	**0.60**	0.30	-0.75	**0.21**	0.16	**0.46**	0.00	*-0.23*	*-0.44*	**0.06**	**0.35**	0.28	-0.10
1.0 m^2/fattening pig	**0.62**	0.07	0.47	-1.65	*-0.61*	0.39	-0.78	*-0.02*	-0.07	0.08	-0.11	*-0.68*	*0.15*	-0.45
Free-range														
No free-range, no daylight in the barn[1]	0	0	0	0	**0**	0	0	**0**	**0**	**0**	*0*	0	0	*0*
No free-range, daylight in the barn	**1.44**	**0.90**	**1.19**	**1.02**	-0.09	**0.35**	**0.49**	*-0.86*	-0.22	-0.16	0.04	-0.48	**1.15**	0.36
0.7 m^2/fattening pig free range	-0.91	-1.30	-1.18	-0.98	-1.22	-1.39	-0.01	-0.56	*-1.38*	*-1.72*	**0.19**	*-1.10*	-0.90	**0.79**
1.0 m^2/fattening pig free range	*-1.14*	*-1.86*	*-1.51*	*-1.86*	*-1.54*	*-1.64*	*-0.22*	-0.56	-1.24	-1.53	0.01	**0.13**	*-2.62*	0.64
Bedding														
Concrete floor with small amount of litter[1]	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*0*	**0**	**0**
Straw or sawdust (5-10 cm)	*-0.42*	*-0.64*	*-0.13*	*-1.14*	*-0.40*	*-0.87*	*-0.74*	*-0.27*	*-0.38*	*-0.37*	*-0.12*	**0.57**	**0.01**	*-0.30*
Group size														
8-20 fattening pigs per group[1]	0	**0**	0	0	**0**	**0**	**0**	**0**	*0*	0	*0*	*0*	**0**	**0**
8-30 fattening pigs per group	*0.33*	*-0.32*	*0.23*	**0.13**	-0.43	-0.31	*-0.22*	0.12	0.06	**0.26**	0.06	**0.26**	*-1.33*	**0.02**
>40 fattening pigs per group	**0.38**	**0.01**	**0.26**	*-0.80*	*-0.50*	*-0.76*	-0.17	*-0.36*	**0.36**	*-0.12*	**0.11**	0.07	-0.11	*-0.45*
Enrichment														
Metal chain with ball[1]	0	**0**	**0**	0	0	*0*	**0**	*0*	0	0	0	0	**0**	**0**
Wood, sturdy rope, straw	*-0.05*	-1.01	*-0.26*	**0.96**	*-0.01*	0.26	**0.00**	0.19	*-0.19*	*-0.88*	**0.05**	**0.09**	-0.22	*-0.38*
Straw, roughage	**0.36**	*-1.58*	-0.03	*-0.11*	**0.19**	**0.58**	*-0.26*	**0.27**	**0.41**	**0.12**	*-0.09*	*-0.10*	*-0.89*	-0.07

Continued

Table 3.4 (Continued) Part-worths per respondent for fattening pig farmers (levels with highest part-worths shown in bold; levels with lowest part-worths shown in italic)

Respondent	1	*2*	3	*4*	5	6	*7*	8	9	11	*12*	*13*	*14*	15
Castration														
Castration allowed[1]	*0*	**0**	**0**	**0**	*0*	**0**	**0**	**0**	*0*	**0**	*0*	**0**	*0*	**0**
Castration not allowed	**0.07**	*-0.49*	*-0.04*	*-0.70*	**0.21**	*-0.25*	*-0.16*	*-0.09*	0.25	*-0.44*	**2.90**	*-0.04*	**0.40**	*-0.62*
Tail docking														
Tail docking allowed[1]	*0*	**0**	*0*	**0**	**0**	**0**	**0**	**0**	*0*	**0**	*0*	**0**	**0**	*0*
Tail docking not allowed	**0.24**	*-0.82*	**0.13**	*-0.20*	*-0.79*	*-0.09*	*-0.16*	*-0.09*	0.25	*-1.27*	**0.07**	*-0.87*	*-0.60*	**0.05**

[1] Reference level

Cluster analysis

In the case of broiler farmers, only the two-cluster solution yielded mean values of the cluster-wise Jaccard similarities higher than 0.75 for each cluster, with values of 0.83 for Cluster 1 and 0.84 for Cluster 2. This indicates that the two-cluster solution resulted in valid and stable clusters (Hennig, 2014). Hence, two clusters were formed on the basis of the estimated part-worths. Details about the cluster solutions are provided in Table 3A.2 in Appendix 3A. Fisher's exact test for categorical variables and the Mann-Whitney U-test for ordered variables were performed to test for differences in the respondents' demographic and farm characteristics between the two clusters. No significant differences were found at the 95% confidence level. The results of the test statistics are provided in Table 3A.3 in Appendix 3A. Figure 3.4 shows that famers in Cluster 1 were more focused on a single aspect of the production system, the provision of free-range ('Free-range focused'), while farmers in Cluster 2 tended to consider the production system as a whole ('Multi-attribute focused').

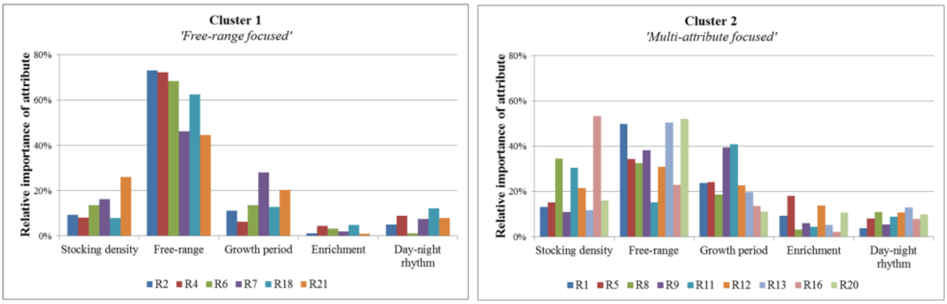


Figure 3.4 Relative importance of attributes for the respondents in each cluster of broiler farmers (R = respondents)

Table 3.5 presents the mean conjoint part-worths per cluster. Differences between the mean conjoint part-worths per cluster were tested using the independent samples t-test. Differences were significant at the 5% critical level in the case of stocking density levels of 38 kg/m^2 and 27.5 kg/m^2. Also, significant differences were found between the two clusters for the levels of the free-range attribute ($P < 0.05$). Regarding the levels with the highest utilities per attribute, there were no differences between the clusters, except for stocking density. In the case of the 'Free-range focused' cluster, 38 kg/m^2 was the most preferred level, while the 'Multi-attribute focused' cluster preferred the level of 42 kg/m^2. However, there were differences in the degree

Table 3.5 Mean conjoint part-worths and associated standard errors for the two clusters of broiler farmers (numbers in bold indicate the levels with the highest preference)

Levels	Cluster 1 ‘Free-range focused’	Cluster 2 ‘Multi-attribute focused’	Independent samples t-test *p*-value
Stocking density			
42 kg/m^2[a]	0	**0**	
38 kg/m^2	**0.36** (0.26)	-0.61 (0.20)	0.010
31 kg/m^2	0.19 (0.22)	-0.35 (0.16)	0.065
27.5 kg/m^2	0.23 (0.22)	-0.69 (0.22)	0.014
Free-range			
No free-range, no daylight in the barn[a]	**0**	**0**	
No free-range, daylight in the barn	-1.18 (0.31)	-0.28 (0.16)	0.014
Covered veranda 12x12 cm/chicken	-2.56 (0.21)	-0.93 (0.20)	0.000
Outdoor access 1m^2/chicken	-2.69 (0.27)	-1.22 (0.17)	0.000
Growth period			
40-42 days[1]	**0**	**0**	
45 days	-0.15 (0.22)	-0.26 (0.18)	0.727
56 days	-0.34 (0.28)	-0.43 (0.22)	0.811
63 days	-0.39 (0.34)	-0.73 (0.29)	0.469
Enrichment			
No enrichment[1]	**0**	**0**	
Whole grains and bales of straw	-0.10 (0.06)	-0.26 (0.10)	0.239
Day-night rhythm			
Unnatural, min. 4 h of uninterrupted darkness/day[1]	0	0	
Natural, min. 6 h of uninterrupted darkness/day	**0.17** (0.08)	**0.16** (0.08)	0.906
Natural, min. 8 h of uninterrupted darkness/day	0.03 (0.13)	0.10 (0.07)	0.641

[1] Reference level

of preference of different levels. In terms of free range, the ‘Free-range focused’ cluster had stronger objections towards deviations from the conventional level than the ‘Multi-attribute focused’ cluster. In contrast, for the length of growth period and enrichment, the negative preferences about deviations from the conventional levels were weaker for the ‘Free-range focused’ cluster than for the ‘Multi-attribute focused’ cluster. Regarding stocking density, the ‘Free-range focused’ cluster actually preferred the levels different from the conventional level. As for day-night rhythm, no considerable differences were found between the two clusters. In summary, although farmers in the ‘Free-range focused’ cluster had strong objections towards free-range access, they were less negative about changes (compared to the conventional system) in other attributes than the ‘Multi-attribute focused’ cluster. Farmers in the ‘Multi-attribute focused’ cluster had a stronger preference towards the conventional system for all attributes, with the exception of day-night rhythm, than the ‘Free-range focused’ cluster. In the case of fattening pig farmers, no cluster solution was found that yielded a mean Jaccard similarity value equal to or greater than 0.75 for each cluster, which was the criterion for identifying valid and stable clusters. Therefore no valid and stable clusters could be found for fattening pig farmers. Details on the cluster solutions are presented in Table 3A.4 in Appendix 3A.

External validation of results

The results of the external validation by experts are presented in Table 3.6 for broiler farmers and Table 3.7 for fattening pig farmers. In general, experts confirmed the main findings of the survey, which characterized a typical broiler and fattening pig producer in terms of their demographic and farm characteristics and preferences about production systems. The experts held similar views regarding the main findings. However, they indicated some points of discussion. Regarding broiler production at the national level, experts indicated some differences between the average farmer in Noord-Brabant and Limburg and in the rest of the country. It was indicated that average farm size in Noord-Brabant and Limburg was larger than the average farm size in the rest of the Netherlands. In addition, in the rest of the Netherlands, a higher proportion of farmers’ family income comes from sources outside broiler production than in the area of Noord-Brabant and Limburg. Farms in the rest of the Netherlands tend to be less specialized, and often combine several agricultural activities (e.g., broiler production and arable farming). This latter remark was also indicated by Expert 3 as relevant for fattening pig production.

Table 3.6 Results of the survey, in terms of characteristics of a typical broiler farmer, and their representativeness at regional and national level according to expert opinion

	Survey			Percentage of farmers in the area of Noord-Brabant and Limburg			Percentage of farmers in the Netherlands		
	Percentage respondents	Lower bound 95% CI	Upper bound 95% CI	Expert 1	Expert 2	Expert 3	Expert 1	Expert 2	Expert 3
A typical broiler farmer									
Demographic and farm characteristics									
has a conventional production system.	95	86	100	80	90	80	80	80	80
has a medium-scale or large-scale farm (≥ 90.000 animal places).	72	53	91	70	80	60	50	50	60
has invested in farm expansion in the last 5 years.	65	44	86	20	90	50	20	70	50
has been working as self-employed in the farm for at least 10 years.	69	46	92	80	70	90	80	70	90
earns at least 80% of the family income from broiler farm activities.	86	71	100	90	100	80	30	70	80
The choice of production system									
prefers a production system that largely resembles the conventional system.	100[1]	-	-	90	100	70	70	90	70
strongly prefers systems with no covered veranda and outdoor access.	80	60	100	80	90	80	60	80	80

[1] Confidence interval cannot be calculated.

Table 3.7 Results of the survey, in terms of characteristics of a typical fattening pig farmer, and their representativeness at regional and national level according to expert opinion

	Survey			Percentage of farmers in the area of Noord-Brabant and Limburg				Percentage of farmers in the Netherlands			
	Percentage respondents	Lower bound 95% CI	Upper bound 95% CI	Expert 1	Expert 2	Expert 3	Expert 4	Expert1	Expert 2	Expert 3	Expert 4
The typical fattening pig farmer											
Demographic and farm characteristics											
has a conventional production system.	100[1]	-	-	90	70	70	90	80	70	80	90
has a medium-scale or large-scale farm (≥ 2.000 animal places).	47	22	72	70	70	50	40	40	60	50	30
has invested in farm expansion in the last 10 years.	67	43	91	70	70	70	50	40	70	70	40
has been working as self-employed in the farm for at least 15 years.	77	54	100	90	90	70	90	90	80	70	90
earns at least 80% of the family income from fattening pig farm activities.	87	70	100	70	70	30	80	60	80	30	70
The choice of production system											
prefers a production system that largely resembles the conventional system.	85	66	100	90	90	80	90	90	90	80	90
strongly prefers systems with no free-range access.	85	66	100	90	100	90	100	90	80	90	100

[1] Confidence interval cannot be calculated.

Discussion and conclusions

The objective of this study was to explore farmers' intrinsic motivation to adopt production systems that improve AW, by eliciting the preferences of Dutch broiler and fattening pig farmers for different AW-related characteristics of production systems. Preferences were studied in the framework of the multi-attribute conjoint model.

The majority of both broiler and fattening pig farmers in our sample had medium-scale or large-scale farms and used conventional production systems. The main source of family income was the farm, which had been intensively expanded during the last five to ten years. In terms of their preferences, farmers preferred conventional practices and had negative preferences about free-range systems. More specifically, free-range was the most important attribute in the decision-making for both broiler and fattening pig farmers. Farmers, on average, indicated a low preference for the provision of free-range access. Hence, farmers were reluctant to provide a free-range area at the farm. In the case of fattening pig farmers, indoor space was the second most important attribute (relative importance weight = 14.99%). At an aggregate level, respondents preferred an indoor space of, at most, 0.9 m^2 per fattening pig. Other fattening pig production system attributes, such as castration, enrichment, group size, bedding, and tail docking, scored almost equally important. In the case of broiler farmers, growth period (relative importance weight = 20.44%) and stocking density (relative importance weight = 19.22%) scored similarly, as the second most important attributes. Day-night rhythm (relative importance weight = 8.12%) and enrichment (relative importance weight = 5.99%) were assigned the lowest importance. A cluster analysis was carried out based on the estimated part-worths; two clusters of broiler farmers were identified. The 'Free-range focused' cluster evaluated a production system by focusing on a single aspect, the provision of free-range access, while the 'Multi-attribute focused' cluster took a more holistic view and included multiple attributes in their evaluation. There were no significant differences in the levels with the highest utilities, except for stocking density. However, the strength of preferences did differ between the two clusters. In the case of fattening pig farmers, no clusters were identified.

The preferences elicited in this study suggest that farmers have a low intrinsic motivation to adopt production systems that improve AW. However, these preferences might not solely reflect farmers' intrinsic motivation, as the effect of external factors could not be completely eliminated. Therefore the elicited preferences could indicate either that (1) farmers do not have strong intrinsic motivation, or (2) that preferences toward AW are partially dictated by external factors and constraints. In both cases, it is likely that the level of on-farm AW will be determined by external and farm-specific factors.

Although farmers' preferences about AW-related attributes of production systems have not been investigated in detail, some of our findings are supported by evidence from literature and recent developments in the field. The result that fattening pig farmers preferred 'no castration' to 'castration', is consistent with current practice regarding castration, i.e., approximately 75% of the boars are not castrated in the Netherlands (LEI, 2014). Also, this study showed that 'tail docking' was preferred to 'no tail docking'. This is in line with (Bracke et al., 2013) who found that conventional farmers view tail docking as a necessary practice and that farmers prefer to dock tails rather than risk tail biting.

The main results, that farmers prefer conventional production practices and have negative preferences about free-range systems, were confirmed through expert validation. Experts confirmed that these findings hold for the majority of Dutch broiler and fattening pig farmers. In terms of farm characteristics, a few differences between the study area of Noord-Brabant and Limburg and rest of the country were indicated. Experts indicated that at country level, the average farm size was smaller and farms were less specialized than in the study area of Noord-Brabant and Limburg (Hoste et al., 2011). Consequently, results might not be applicable to smaller and less specialized farms. However, a large proportion of meat production is coming from specialized medium-scale and large-scale farms, which were represented in the study.

The present study provided insights into the preferences of broiler and fattening pig farmers. Results showed that farmers prefer conventional production practices, and that they do not have a strong intrinsic motivation to switch to a production system that provides higher levels of AW than the minimum legal requirements. Therefore, the results of the paper suggest that farmers will need to be triggered by external factors to adopt higher AW standards. These external factors could be provided by market initiatives or government policies.

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Appendix 3A

Table 3A.1 Demographic and socio-economic characteristics of broiler and fattening pig farmers in the sample

Broiler farmers				Fattening pig farmers			
Variable	N	Mean	SD	Variable	N	Mean	SD
Study group *(1= study group 1 and 2, 2= study group 3)*	22	1.32	0.48	Study *group (1= study group 1, 2= study group 2, 3=study group 3)*	13	2.08	0.86
Age	21	46.43	8.45	Age	14	46.43	8.56
Gender *(1=male, 2=female)*	22	1.05	0.21	Gender *(1=male, 2=female)*	15	1.00	0.00
Years in farming as self-employed	16	18.25	11.31	Years in farming as self-employed	13	23.69	11.07
Sources of family income *(1=100% from farm activities, 2=80% from farm activities, 3=50% from farm activities, 4=20% from farm activities)*	21	1.52	0.87	Sources of family income *(1=100% from farm activities, 2=80% from farm activities, 3=50% from farm activities, 4=20% from farm activities)*	15	1.60	0.74
Production system *(1=conventional, 2=alternative)*	22	1.05	0.21	Production system (1=conventional, 2=alternative)	14	1.00	0.00
Number of animal places *(1=less than 30,000, 2=30,000-60,000, 3=60,001-90,000, 4=more than 90,000)*	22	3.45	1.06	Number of animal places *(1=less than 250, 2=250-1,000, 3=1,001-2,000, 4=2,001-4,000, 5=more than 4,000)*	15	3.60	0.91
Latest expansion of the farm *(1=less than 5 years ago, 2=5-10 years ago, 3=11-20 years ago, 3=more than 20 years ago)*	20	1.70	1.13	Latest expansion of the farm *(1=less than 5 years ago, 2=5-10 years ago, 3=11-20 years ago, 3=more than 20 years ago)*	15	1.93	1.03
Number of extra animal places built during the expansion	17	43,912.76	30,398.52	Number of extra animal places built during the expansion	13	1,983.85	2,503.14
Market *(1=domestic, 2=international, 3=domestic and international)*	22	2.41	0.85	Market *(1=domestic, 2=international, 3=domestic and international)*	15	1.53	0.92

Table 3A.2 Mean cluster-wise Jaccard similarities for broiler farmers

	2-cluster solution	3-cluster solution	4-cluster solution	5-cluster solution
Cluster 1	0.83	0.79	0.86	0.83
Cluster 2	0.84	0.67	0.79	0.74
Cluster 3	-	0.58	0.73	0.82
Cluster 4	-	-	0.72	0.80
Cluster 5	-	-	-	0.60

Table 3A.3 Demographic and farm characteristics of broiler producers per cluster

	Cluster 1			Cluster 2			
Variable	N	Mean	SD	N	Mean	SD	p-value
Study group *(1= study group 1 and 2, 2= study group 3)*	6	1.67	0.52	9	1.22	0.44	0.14[2]
Age	6	47.17 (44[1])	7.55	9	44.56 (44[1])	8.78	0.69[3]
Gender *(1=male, 2=female)*	6	1.00	0.00	9	1.11	0.33	1.00[2]
Years in farming as self-employed	3	21.33 (20[1])	13.05	7	15.57 (14[1])	11.97	0.38[3]
Sources of family income *(1=100% from farm activities, 2=80% from farm activities, 3=50% from farm activities, 4=20% from farm activities)*	6	2.00	1.26	8	1.25	0.46	1.00[2]
Production system *(1=conventional, 2=alternative)*	6	1.00	0.00	9	1.11	0.33	1.00[2]
Number of animal places *(1=less than 30,000, 2=30,000-60,000, 3=60,001-90,000, 4=more than 90,000)*	6	3.33	1.21	9	3.56	1.01	1.00[2]
Latest expansion of the farm *(1=less than 5 years ago, 2=5-10 years ago, 3=11-20 years ago, 3=more than 20 years ago)*	6	1.67	1.03	8	1.88	1.46	1.00[2]
Number of extra animal places built during the expansion	6	39,538.33 (46,000[1])	19,241.66	7	48,857.14 (46,000[1])	43,017.16	0.94[3]
Market *(1=domestic, 2=international, 3=domestic and international)*	6	2.67	0.82	9	2.44	0.88	1.00[2]

[1] Median

[2] Fisher's exact test

[3] Mann-Whitney U test

Table 3A.4 Mean cluster-wise Jaccard similarities for fattening pig farmers

	2-cluster solution	3-cluster solution	4-cluster solution	5-cluster solution
Cluster 1	0.51	0.69	0.79	0.79
Cluster 2	0.79	0.66	0.58	0.53
Cluster 3	-	0.50	0.70	0.80
Cluster 4	-	-	0.68	0.66
Cluster 5	-	-	-	0.64

Appendix 3B

Exchange algorithm

1. Create an orthogonal fractional factorial cyclic design and calculate D-optimality ($D_{original}$).
2. Eliminate infeasible profiles from the full factorial design (Candidate set for Block A).
3. Create a D-efficient design for the 1st block of pairwise comparison tasks (Block A) with Dopt.design (R-package DoE.wrapper) procedure from the candidate set for Block A.
4. Create the 2nd block of pairwise comparison tasks (Block B) through a cyclic design.
5. Calculation of D-optimality of the generated two blocks (D_1).
    a. Design matrix: X.
    b. Normalized variance-covariance matrix of the predictors: (X'X/N), where N is the number of rows in the design matrix.
    c. The kth root of the determinant of the normalized variance-covariance matrix: D=|(X'X/N)|^(1/k), where k is the number of columns in the design matrix.
6. Check if $D_1/D_{original} < 0.9$, if yes go on to 7; if no stop here, because final design is found.
7. Identify infeasible profiles in Block B.
8. Create candidate set for Block B.

a. Keep the levels of those attributes of which the levels are always feasible fixed, and include profiles with every possible combination of the levels that are now infeasible.

9. Set seed.
10. Random sampling from candidate set for Block B and exchange infeasible profiles with feasible profiles from the candidate set for Block B.
11. Calculate D-optimality of the current design (D_2).
12. Save the design with max D_2 (D_{max}).
13. Go back to 10 and repeat 11, 12 for M iterations.
14. Check $D_{max}/D_{original} < 0.9$, if yes, go back to 9 and choose a different seed; if no, stop here, because final design is found.

References

Bracke, M.B.M., Lauwere, C.C., Wind, S.M., Zonerland, J. (2013). Attitudes of Dutch Pig Farmers Towards Tail Biting and Tail Docking. Journal of Agricultural and Environmental Ethics, 26:847-868.

De Lauwere, C., van Asseldonk, M., van 't Riet, J., de Hoop, J., ten Pierick, E. (2012). Understanding farmers' decisions with regard to animal welfare: The case of changing to group housing for pregnant sows. Livestock Science, 143:151-161.

Edwards-Jones, G. (2006). Modelling farmer decision-making: concepts, progress and challenges. Animal Science, 82:783-790.

EZ. (2013). Monitor Duurzaam Voedsel 2012. (Den Haag: Ministerie van Economische Zaken, 2013). Available at http://www.bio-plus.nl/fileadmin/filelist/afbeeldingen/Nieuwsbrieven/monitor-duurzaam-voedsel-2012.pdf. Accessed 08-05-2014.

Gocsik, É., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2013). Mid-term financial impact of animal welfare improvements in Dutch broiler production. Poultry Science, 92:3314-3329.

Gocsik, É., Saatkamp H.W., de Lauwere, C.C., Oude Lansink, A.G.J.M. (2014a). A Conceptual Approach for a Quantitative Economic Analysis of Farmers' Decision-Making Regarding Animal Welfare. Journal of Agricultural & Environmental Ethics, 27:287-308.

Gocsik, É., Voermans, G., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2014b). Economic feasibility of animal welfare improvements in Dutch intensive livestock production: A comparison between broiler, laying hen, and fattening pig farms. Working paper. Wageningen University.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. (2009). Multivariate Data Analysis. Prentice Hall, NJ, USA.

Hansson, H., Lagerkvist, C.J. (2014). Defining and measuring farmers' attitudes to farm animal welfare. Animal Welfare, 23:47-56.

Hennig, C. (2006). Cluster-wise assessment cluster stability. Research report no. 271. Department of Statistical Science, University College London, London.

Hennig, C. (2014). "Package 'fpc'". Available at http://cran.r-project.org/web/packages/fpc/fpc.pdf. Accessed 08-05-2014.

Hoste, R., Baltussen, W., Zeewuster, H., van der Veen, H., Jager, J. (2011). Toekomstperspectief van varkensbedrijven in Oost-Nederland - Quick scan. Agricultural Economics Research Institute, WUR, The Hague, the Netherlands. Available at http://edepot.wur.nl/203129. Accessed 08-05-2014.

Hubbard, C., Bourlakis, M., Garrod, G. (2007). Pig in the middle: farmers and the delivery of farm animal welfare standards. British Food Journal, 109:919-930.

Johnson, R.M. (1987) Adaptive conjoint analysis. in S. Software (ed.), Proceedings of the Sawtooth Software Conference on Perceptual Mapping, Conjoint Analysis, and Computer Interviewing, pp. 253-265. Sawtooth Software, Ketchum, ID.

Knowler, D., Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy, 32:25-48.

Kuhfeld, W.F. (2006). Construction of efficient designs for choice experiments. in R. Grover and M. Vriens (eds.), The Handbook of Marketing Research: Uses, Misuses, and Future Advances. SAGE Publications Inc., California.

LEI. (2014). Afgelopen vijf jaar significant minder varkens gecastreerd. LEI, Wageningen UR, The Hague, the Netherlands, and Livestock Research and Varkens Innovatie Centrum Sterksel, Lelystad, the Netherlands. Available at http://www.wageningenur.nl/nl/Expertises-Dienstverlening/Onderzoeksinstituten/lei/show/Afgelopen-vijf-jaar-significant-minder-varkens-gecastreerd.htm. Accessed 09-05-2014.

Padel, S. (2001). Conversion to organic farming: A typical example of the diffusion of an innovation? Sociologia Ruralis, 41:40-61.

PPE. (2014). Voorlopige Jaarcijfers 2013. Pluimveevleessector. (Preliminary statistics for the poultry sector 2013)". Productschap Pluimvee and Eieren, Zoetermeer, the Netherlands.

PVV. (2014). Voorlopige Jaarcijfers 2013. Sector Varkens. (Preliminary statistics for the fattening pig sector 2013)". Productschap Vee and Vlees, Zoetermeer, the Netherlands.

R_Development_Core_Team. (2010). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing.

Schoon, B., te Grotenhuis, R. (2000). Values of farmers, sustainability and agricultural policy. Journal of Agricultural & Environmental Ethics, 12:17-27.

Spooner, J., Schuppli, C., Fraser, D. (2013). Attitudes of Canadian pig producers toward animal welfare. Journal of Agricultural and Environmental Ethics, DOI: 10.1007/s10806-013-9477-4

Van Huik, M.M., Bock, B.B. (2007). Attitudes of Dutch pig farmers towards animal welfare. British Food Journal, 109: 879-890.

Vanhonacker, F., Verbeke, W. (2014). Public and Consumer Policies for Higher Welfare Food Products: Challenges and Opportunities. Journal of Agricultural and Environmental Ethics. 27:153-171.

Verbeke, W. (2009). Stakeholder, citizen and consumer interests in farm animal welfare. Animal Welfare, 18:325-333.

Witte, R.S., Witte, J.S. (2010). Statistics. John Wiley & Sons, Inc., NJ, USA.

Zegers, F.E., ten Berge, J.M.F. (1985). A Family of Association Coefficients for Metric Scales. Psychometrika 50:17-24.

Chapter 4

Willingness of Dutch broiler and fattening pig farmers to convert to production systems with improved welfare

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Abstract

The present study investigated Dutch broiler and fattening pig farmers' willingness-to-convert to alternative production systems with higher animal welfare standards compared to conventional production systems, and explored the main barriers to the adoption of these alternative systems. Alternative production systems were categorized according to whether farmers were required to make reversible or irreversible changes to the current farm. Results show that both broiler and fattening pig farmers were more willing to adopt systems requiring reversible changes in the farm than systems requiring irreversible changes. Many farmers were willing to convert to a system requiring reversible changes if they knew they could earn the same income as they did in their current system, i.e., if the increased costs due to higher AW standards were compensated. The study highlights a number of reasons for farmers' reluctance to switch to alternative systems: perceived uncertainty about price premiums, lack of space on the farm, and scarcity of land available for agricultural production at regional and country level. A higher risk of disease spread in free-range broiler production systems was mentioned by many farmers as a potential barrier. In addition, the existing farm-setup sometimes limits the adoption of new systems. Farmers' reluctance appears not to be caused by a negative attitude towards animal welfare as such, but more related to the financial consequences of adopting alternative systems. Hence, animal welfare policies and market initiatives need to offer a long-term perspective and require commitment from all stakeholders in the supply chain.

Keywords: Farmer's decision-making, Animal welfare, Barriers to adoption, Broiler production, Pig production

Introduction

Dutch broiler and pig farmers in the Netherlands can voluntarily choose from a range of production systems, which comply with animal welfare (AW) standards that exceed the legislative minimum standards (Immink et al., 2013; Vanhonacker and Verbeke, 2014). A farmer's decision to adopt a new production system is affected by the farmer's intrinsic motivation to produce according to higher AW standards and by the choice set that is determined by external factors and certain farm-specific factors. Gocsik et al. (2014b) found that farmers did not have a strong intrinsic motivation to convert to a production system with higher AW standards. This study also suggested that farmers' intrinsic motivation was constrained by external factors that were beyond the farmers' control and by farm-specific factors such as farm size and farm set-up. Hence, the farmers' default choice is often a conventional production system. Nevertheless, it is likely that farmers would be willing to adopt higher AW standards if external and farm-specific factors are favorable for the adoption (Gocsik et al., 2014b).

The literature on farmers' decisions to adopt new production systems and other investments also shows that the choice of production system is influenced by external factors that are outside the farmer's control, such as the legislative environment and market forces, and by farm-specific factors such as farm set-up and farm size (Greiner and Gregg, 2011). De Lauwere et al. (2012) suggest that external factors, such as credit availability and permit procedures, are possible bottlenecks in changing to group housing for pregnant sows. Uncertainty about future legislation may also influence farmers' decisions about production practices (Tuyttens et al., 2008; de Lauwere et al., 2012). Furthermore, Gocsik et al. (2014b) found that land availability and price premiums also affect farmers' decisions to adopt production systems that improve AW. Previous studies also identified socio-economic and demographic factors associated with farms and farmers as relevant to the adoption decision (de Buck et al., 2001; Oude Lansink et al., 2003; Gocsik et al., 2014a). However, these factors are of less importance when designing market initiatives, as socio-economic and demographic factors are relatively fixed and difficult to influence. In contrast, external factors such as market conditions are more flexible to changes. Therefore, exploring how external factors influence farmers' participation in market initiatives may provide insights that are useful for designing viable production systems with higher levels of AW.

The objective of this study was twofold. Firstly, to explore the conditions in which farmers would be willing to convert to an alternative system, with a particular focus on the trade-off between preferences and farmers' family income. Secondly, to identify the main barriers that prevent farmers from adopting alternative production systems. The remainder of this paper is structured as follows. Section 2 describes the materials and methods, which is followed by the presentation of the results in Section 3. Main business and policy implications and conclusions are discussed in Section 4.

Materials and methods

Questionnaire

A survey was carried out with 22 broiler farmers and 15 pig farmers in the province of Noord-Brabant in the Netherlands from October to December 2013. The survey was administered using a paper and pencil questionnaire among six study groups. The questionnaire was pre-tested face-to-face with a broiler farmer prior to the actual data collection, and the questionnaire was revised based on his comments. The resulting questionnaire consisted of three parts. The first part contained questions regarding demographic and socio-economic characteristics. The second part contained questions about the respondent's perception of external factors, which might constrain the adoption of a new production system. The third part included questions about the change in family income that the respondent would require in order to be willing to convert to an alternative system. The questionnaire for the fattening pig farmers was structured in the same way.

Sample

The responses of 15 broiler farmers (out of 22) and 13 fattening pig farmers (out of 15) were useable for the analysis of willingness-to-convert. The demographic and socio-economic characteristics of the respondents included in the analysis are briefly described here. The details of the whole sample are provided in Gocsik et al. (2014b).

Regarding broiler farmers, the average age of respondents was 45.60 (SD[5] = 8.13). The majority of respondents were male and had a medium-scale or large-scale farm with a conventional production system. The respondents had, on average, 17.30 years of experience in farming (SD = 11.88). With regard to fattening pig farmers, the average age of the respondents was 46 (SD = 8.5) (Table 4.1). They were all male, with an average of 23.25 years of experience in farming (SD = 11.44). They all had a medium-scale or large-scale farm with a conventional production system. For the majority of respondents in both surveys, the main source of family income was farming. On average, the respondents had expanded their farm less than ten years

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[5] SD = standard deviation

Table 4.1 Demographic and socio-economic characteristics of broiler and fattening pig farmers in the sample

Broiler farmers				Fattening pig farmers				
Variable	N	Mean	SD	Variable	N	Mean	SD	p-value
Study group *(1= study group 1 and 2, 2= study group 3)*	15	1.40	0.51	Study *group (1= study group 1, 2= study group 2, 3=study group 3)*	12	2.00	0.86	-
Age	15	45.60	8.13	Age	13	46.00	8.5	0.650[1]
Gender *(1=male, 2=female)*	15	1.07	0.26	Gender *(1=male, 2=female)*	13	1.00	0.00	1.000[2]
Years in farming as self-employed	10	17.30	11.88	Years in farming as self-employed	12	23.25	11.44	0.283[1]
Sources of family income *(1=100% from farm activities, 2=80% from farm activities, 3=50% from farm activities, 4=20% from farm activities)*	14	1.57	0.94	Sources of family income *(1=100% from farm activities, 2=80% from farm activities, 3=50% from farm activities, 4=20% from farm activities)*	13	1.39	0.51	1.000[2]
Production system *(1=conventional, 2=alternative)*	15	1.07	0.26	Production system (1=conventional, 2=alternative)	13	1.00	0.00	1.000[2]
Number of animal places *(1=less than 30,000, 2=30,000-60,000, 3=60,001-90,000, 4=more than 90,000)*	15	3.47	1.06	Number of animal places *(1=less than 250, 2=251-1,000, 3=1,001-2,000, 4=2,001-4,000, 5=more than 4,000)*	13	3.77	0.83	-
Latest expansion of the farm *(1=less than 5 years ago, 2=5-10 years ago, 3=11-20 years ago, 3=more than 20 years ago)*	14	1.79	1.25	Latest expansion of the farm *(1=less than 5 years ago, 2=5-10 years ago, 3=11-20 years ago, 3=more than 20 years ago)*	13	1.77	1.01	1.000[2]
Number of extra animal places built during the expansion	13	44,576.92	33,206.33	Number of extra animal places built during the expansion	11	2,290	2,613.56	-
Market *(1=domestic, 2=international, 3=domestic and international)*	15	2.53	0.83	Market *(1=domestic, 2=international, 3=domestic and international)*	13	1.53	0.92	1.000[2]

[1] Mann-Whitney U-test

[2] Fisher’s exact test

ago. No significant differences were found between the broiler and fattening pig farmers in terms of their demographic and socio-economic characteristics. Differences between broiler and fattening pig farmers were not tested for the variables that depend on farm type; these variables were: study group, number of animal places, and number of animal places built during the expansion.

Perception of external factors

External factors were evaluated on a seven-point Likert-scale ranging from one to seven. The following external factors were included: land availability, length of time for land acquisition, certainty about price premiums, level of price premiums (whether or not they cover extra costs), and level of transition costs. These factors were identified by Gocsik et al. (2014a) as possible constraints for the adoption of production systems with higher AW standards.

Contingent valuation

The contingent valuation method was used to reveal the farmer's monetary trade-off for alternative production systems (Bennett and Larson, 1996; Bennett, 1997). Broiler and pig farmers were asked to indicate their willingness-to-convert from a conventional system to an alternative system, with consequences for family income. Before respondents started with the task, it was necessary to ensure that respondents had the same reference system. Although the majority of the respondents had a conventional system, small differences might occur across farms. Respondents were, therefore, presented with a description of the conventional system and were asked to consider this as the reference system for the questions regarding the monetary trade-offs (Figure 4.1 and Figure 4.2). Next, respondents were presented with four tasks; each task compared the conventional reference system with an alternative system. Four alternative systems were considered. These systems were either in current use, or hypothetical but technically feasible. The description of each of these four systems is referred to as a profile. The broiler profiles were described on the basis of five attributes: stocking density, provision of free-range area, length of growth period, provision of enrichment, and period of darkness per day. With regard to the fattening pig profiles, seven attributes were defined: indoor space, provision of free-range, bedding, group size, enrichment materials, castration, and tail docking. The profiles were designed in such a way that they varied in terms of the reversibility of the changes required to adopt a given a system. In the analysis, two categories of reversibility were distinguished: reversible in the short to medium term and irreversible. The former concerned changes that do not require large investments and construction, and where it would be possible to return to the conventional situation in the short to medium term. The latter category concerned large investments, such as building a covered veranda or acquiring land. However, the distinction between reversible and irreversible was not indicated in the description of the tasks. Figure 4.1 and Figure 4.2 present the conventional and alternative systems for broiler and pig farmers, respectively. In each task, a dichotomous choice question was presented in which respondents had to decide whether they would switch from the conventional system to the alternative system, given that this switch would not affect their family income (Figure 4.3). If their answer was ‘Yes’, they had to indicate on a predefined scale, ranging from 0% to 20%, how much of their family income (including income obtained from farming activities and from other off-farm activities) they would be willing to give up. If they answered ‘No’, they were asked to indicate the increase in family income they would require to switch to the system concerned (on a scale ranging from 5% to more than 50%). When farmers indicated that they would require an increase of more than 50% in their family income, they were asked to indicate the main reason for this.

Conventional broiler system
42 kg/m^2 stocking density
No free range, no daylight in the barn
40-42 days
No enrichment
Min. 4 hours uninterrupted darkness per day

Profile 1: ‘Improved conventional’ ***(reversible)*** 38 kg/m^2 stocking density No free range, no daylight in the barn 45 days Whole grains and bales of straw Min. 6 hours uninterrupted darkness per day	**Profile 2: ‘Outdoor free-range’** ***(irreversible)*** 27.5 kg/m^2 stocking density Outdoor access 1m2/chicken 63 days Whole grains and bales of straw Min. 8 hours uninterrupted darkness per day
Profile 3: ‘Indoor free-range 1’ ***(irreversible)*** 27.5 kg/m^2 stocking density Covered veranda 12x12 cm/chicken 63 days Whole grains and bales of straw Min. 8 hours uninterrupted darkness per day	**Profile 4: ‘Indoor free-range 2’** ***(irreversible)*** 31 kg/m^2 stocking density Covered veranda 12x12 cm/chicken 56 days Whole grains and bales of straw Min. 4 hours uninterrupted darkness per day

Figure 4.1 Description of the conventional broiler system and alternative systems included in the study

Conventional fattening pig system
$0.8\ m^2$/animal indoor space
No free-range, no daylight in the barn
Concrete floor with small amount of litter
8-20 animals per group
Metal chain with ball
Castration allowed
Tail docking allowed

Profile 1: 'Improved conventional, small groups' ***(reversible)***	**Profile 2: 'Improved conventional, large groups'** ***(reversible)***
$1.0\ m^2$/animal indoor space No free-range, no daylight in the barn Concrete floor with small amount of litter 8-20 animals per group Wood, sturdy rope, straw Castration not allowed Tail docking allowed	$1.0\ m^2$/animal indoor space No free-range, daylight in the barn Concrete floor with small amount of litter >40 animals per group Wood, sturdy rope, straw Castration not allowed Tail docking allowed
Profile 3: 'Free-range 1' ***(irreversible)*** $0.7\ m^2$/animal indoor space $0.7\ m^2$/animal free-range Straw/sawdust bedding (5-10 cm) 8-30 animals per group Straw, roughage Castration allowed Tail docking not allowed	**Profile 4: 'Free-range 2'** ***(irreversible)*** $0.9\ m^2$/animal indoor space $1.0\ m^2$/animal free-range Straw/sawdust bedding (5-10 cm) >40 animals per group Wood, sturdy rope, straw Castration not allowed Tail docking not allowed

Figure 4.2 Description of the conventional fattening pig system and alternative systems included in the study

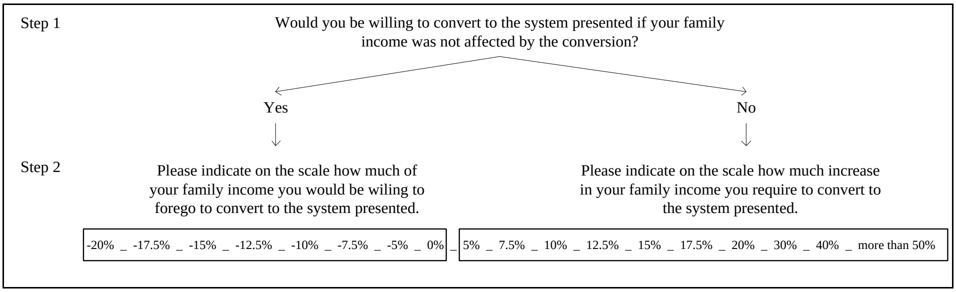

Figure 4.3 Structure of the contingent valuation tasks

It is often claimed that contingent valuation methods do not provide reliable estimates, because of the starting point bias, i.e., respondents have a tendency to say yes at first (Mitchell and Carson, 1989). In order to reduce the possibility of bias, the order of the tasks was varied. Half of the respondents received the tasks in the order of Profile 1, Profile 2, Profile 3, and Profile 4, while the other half of the respondents were presented with the tasks in the order of Profile 2, Profile 1, Profile 4, and Profile 3.

Data Analysis

Contingent valuation

To facilitate the interpretation of results, the values on the scale were grouped into four categories. Figure 4.4 presents the scale, which respondents used to indicate their willingness-to-convert to the alternative systems and the categories which were defined to facilitate interpretation.

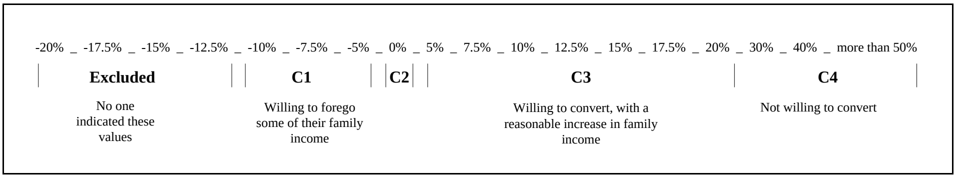

Figure 4.4 Scale used for the willingness-to-convert to an alternative production system and associated categories of willingness-to-convert

The first category (C1) included values ranging from -10% to -5%; respondents in this category were described as willing to forego some of their income to convert to the given system. Respondents in the second category (C2) were described as willing to accept the alternative system, if the family income remained at the same level. Respondents in the third category (C3) were described as willing to accept the alternative system, given a realistic increase in their family income (values from 5% to 20%). An increase of 5% to 20% was considered realistic in the sense that it can probably be achieved under current market circumstances. However, an increase in family income of 30% or more was considered unrealistically high, because it is likely that it cannot be achieved given the current market conditions. Hence, respondents indicating an increase of 30% or more were considered as farmers that were unwilling to convert (C4). No respondents indicated values from -12.5% to -20%, so no category was created for these values.

External validation of results

To check the extent to which the results could be generalized, an expert workshop was organized. A panel of seven experts (i.e., farm advisors and veterinarians) participated in the workshop; three experts specialized in poultry production and four experts specialized in pig production. Experts were presented with a series of statements describing a typical broiler and fattening pig farmer, in terms of their perception of external factors and their willingness-to-convert, consistent with the findings of the survey. They were asked to indicate the percentage of farmers to which these statements applied, at both the regional level (Noord-Brabant and Limburg) and country level. Based on the results of the survey, 95% confidence intervals were established for each statement about the perception of external factors and willingness-to-convert. The results of the survey were deemed generalizable if the answers from the experts were within these confidence intervals (Witte and Witte, 2010).

Results

Perception of external factors

The descriptive statistics for the questions about farmers' perceptions of external factors are presented in Table 4.2. For broiler farmers, the average score for the availability of land was 2.87, indicating that land availability was perceived as rather low. The average score for the length of acquiring land was 5.67, indicating that for the majority of respondents the procedure of land acquisition would take longer than reasonable when adopting new animal welfare production systems. Regarding the certainty about the price premium and the extent to which the price premium covers extra costs, respondents scored, on average, 2.73 and 3.13, respectively. That is, the majority of respondents were rather uncertain about earning a price premium on products with higher AW standards and they perceived that the level of price premium was not sufficient to cover the extra costs incurred due to the alternative production system. The level of transition costs to convert to an alternative system with higher AW standards (the production system was not specified in this question) was, on average, perceived as high (M[6] = 5.87, SD = 1.19).

The results for the pig farmers were similar to those for the broiler farmers. The availability of land was, on average, perceived as neither low or high (M = 4.00, SD = 2.27), while the length of land acquisition was perceived as rather long (M = 5.16, SD = 1.91). The average scores for

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[6] M = mean

Table 4.2 Perception of external factors by broiler and fattening pig farmers

External factor	Scale of measurement	Broiler farmers				Fattening pig farmers				
		N	Mean	Median	SD	N	Mean	Median	SD	p-value[1]
Availability of land	Very low (1) --- Very high (7)	15	2.87	3.00	1.73	13	4.00	4.00	2.27	0.185
Length of land acquisition	Very short (1) --- Very long (7)	15	5.67	6.00	1.68	13	5.16	5.00	1.91	0.496
Certainty about price premium	Very uncertain (1) --- Very certain (7)	15	2.73	2.00	1.87	13	2.46	2.00	1.56	0.821
Price premium covers extra costs	Strongly disagree (1) --- Strongly agree (7)	15	3.13	3.00	2.13	13	2.54	2.00	1.90	0.496
Level of transition costs	Very low (1) --- Very high (7)	15	5.87	6.00	1.19	12	5.33	6.00	1.78	0.821

[1] Mann-Whitney U-test

the certainty about the price premium and the extent to which this price premium covers extra costs were 2.46 and 2.54, respectively. These scores indicate that the majority of respondents perceived that there was uncertainty about the price premium and that the level of price premium was insufficient to cover extra costs. Similarly, the level of transition costs was, on average, perceived as high (M = 5.33, SD = 1.78). No significant differences were found between the perceptions of broiler farmers and fattening pig farmers.

Contingent valuation

The broiler farmers' willingness-to-convert to selected alternative systems is shown in Table 4.3. With regard to the 'Improved conventional' system, one respondent was willing to give up some of his income (10% of family income) and change to this system. Six respondents were willing to convert to the 'Improved conventional' system given the same level of family income. Five respondents required a realistic increase in family income to be willing to change, and three respondents were not willing to change at all. In the case of the 'Outdoor free-range' system, two respondents required a realistic increase in their income, while 13 farmers were not willing to change to this system. For the 'Indoor free-range 1' system, two respondents did not answer this question, for unknown reasons. Two respondents were willing to convert given the same income level, while three respondents required a realistic increase in their income. Eight respondents were not willing to switch at all. In the case of the 'Indoor free-range 2' system, three respondents did not give an answer, for unknown reasons. Three respondents required a realistic increase in their family income to convert to the given system, while nine respondents were not willing to switch at all.

In response to the open-ended question about the reasons for requiring an increase of more than 50% in family income, respondents mentioned one or more reasons. Table 4.4 lists the reasons for each profile. In the case of the 'Improved conventional' system, one farmer required an increase of more than 50% in his family income. He indicated disease risk and extra work, among others, as reasons. In the case of the 'Outdoor free-range system', ten farmers indicated that they would require an increase of more than 50% in their family income. The main reasons given were: the provision of outdoor access, the high space requirements that make it impossible to adopt this system, and the higher risks of animal diseases. Five farmers required an increase in family income of more than 50% for both the 'Indoor free-range 1' and 'Indoor free-range 2' systems. For both these systems, farmers indicated similar reasons for their unwillingness to adopt: the provision of a covered veranda, transition costs, risk of influenza, and more work. Respondents also indicated that the existing barns were not completely

Table 4.3 Number of broiler farmers in each category of willingness-to-convert for the different profiles (alternative production systems)

Willingness-to-convert	Profile 1 'Improved conventional' *(reversible)* (*n* = 15)	Profile 2 'Outdoor free-range' *(irreversible)* (*n* = 15)	Profile 3 'Indoor free-range 1' *(irreversible)* (*n* = 13)	Profile 4 'Indoor free-range 2' *(irreversible)* (*n* = 12)
C1: Yes, and willing to forego some of their family income	1			
C2: Yes, given the same level of family income	6		2	
C3: Yes, given a reasonable increase in family income	5	2	3	3
C4: No	3	13	8	9

Table 4.4 Reasons given by broiler farmers for requiring an increase in family income of more than 50% (the number of respondents that mentioned each reason is indicated in brackets)

Profile 1 'Improved conventional' (*n* = 1)	Profile 2 'Outdoor free-range' (*n* = 10)	Profile 3 'Indoor free-range 1' (*n* = 5)	Profile 4 'Indoor free-range 2' (*n* = 5)
Disease risk	Avian influenza, animal diseases (4)	Avian influenza	Avian influenza
Extra work	Too high transition costs	Covered veranda (2)	Covered veranda
Transition costs	Extra work	Enrichment	Extra work (2)
Lack of room and feasibility	High space requirements, not enough room	Extra work	Lack of room
	Outdoor access (4)	Transition costs (2)	Transition costs (3)
	Impossible	Existing barns do not entirely suit the alternative system	Existing barns do not entirely suit the alternative system
		Given the current legislation it is not feasible	Given the current legislation it is not feasible

suitable for these systems and that the current legislation made it infeasible to adopt these systems.

With regard to fattening pig farmers, Table 4.5 shows that two out of 13 respondents were willing to forego some of their income (i.e., 10% of family income) to convert to the 'Improved conventional, small groups' system. Eight respondents indicated that they were willing to

Table 4.5 Number of fattening pig farmers in each category of willingness-to-convert for the different profiles (alternative production systems)

Willingness-to-convert	Profile 1 'Improved conventional, small groups' *(reversible)* (*n* = 13)	Profile 2 'Improved conventional, large groups' *(reversible)* (*n* = 13)	Profile 3 'Free-range 1' *(irreversible)* (*n* = 13)	Profile 4 'Free-range 2' *(irreversible)* (*n* = 12)
C1: Yes, and willing to forego some of their family income	2	1		
C2: Yes, given the same level of family income	8	5		1
C3: Yes, given a reasonable increase in family income	2	4	2	1
C4: No	1	3	11	10

convert provided they maintain the same income level, while two respondents required a realistic increase in family income. One respondent was not willing to change at all. In the case of the 'Improved conventional, large groups' system, the majority of respondents was willing to accept this system. One respondent was willing to sacrifice some of his income (i.e., 10% of family income). Five respondents were willing to change given the same income level, and four respondents required a realistic increase in their family income. Three respondents indicated that they were not willing to switch to this system. The majority of respondents were unwilling to convert to the 'Free-range 1' (11 out of 13 respondents) and 'Free-range 2' systems (ten out of 12 respondents).

The reasons given by fattening pig farmers for requiring an increase of more than 50% in family income are shown in Table 4.6. In the case of the 'Improved conventional, large groups' system, one farmer indicated that he required an increase of more than 50% in his family income to switch to the system concerned. The large group size (more than 40 animals per group) that is required by the system was indicated as a reason. Five farmers required an increase of more than 50% in family income to switch to the 'Free-range 1' system and six farmers in the case of the 'Free-range 2' system. The reasons given for the 'Free-range 1' and 'Free-range 2' systems were similar; respondents indicated that these systems required large investments and space, and entailed more risks. Further, farmers thought that the consumer demand was not large enough to support such a system (i.e., does not work, market is questionable). In addition, farmers believed that this system could lead to more stress among pigs because tail docking was not allowed.

External validation of results

The results of the expert validation are presented in Table 4.7 for broiler farmers and in Table 4.8 for fattening pig farmers. In the case of broiler farmers, a large variation was observed in expert opinion with regard to the statements about availability of land and length of land acquisition. At regional level, experts indicated values ranging from 20% to 90% for availability of land and from 30% to 100% for the length of land acquisition. At country level, the ranges were even wider. The willingness-to-convert for the alternative systems was generally estimated by the experts as higher than in the survey results, however estimates fell within the confidence interval in the case of Expert 1 and Expert 3. Experts tended to estimate a higher willingness-to-convert at the country level compared to the regional level.

In the case of fattening pig farmers, a large variation was observed in expert opinion for the statement on land availability. Regarding the percentage of farmers at the regional level who perceive land availability as reasonable, Expert 1 and Expert 2 both estimated a lower percentage(20% and 20%, respectively) than the lower bound of the confidence interval of 24%. Whereas, Expert 4 indicated a higher percentage of farmers that perceive land availability as reasonable (80%) compared to the upper bound of 76%. The expert estimates for willingness-to-convert for the alternative systems were usually within the confidence interval. The expert opinions about farmers' willingness-to-convert were similar at regional and at country level.

Table 4.6 Reasons given by fattening pig farmers for requiring an increase in family income of more than 50%

Profile 2 'Improved conventional, large groups' (*n* = 1)	Profile 3 'Free-range 1 (*n* = 5)	Profile 4 'Free-range 2' (*n* = 6)
Group size > 40	Bedding material	Farmer unfriendly system
	Tail docking not allowed	Free-range
	Does not work	High risk
	Large investment, more risks, shorter payback period	Large investment
	Market is questionable	No room for free-range next to the barn
	Lack of space	No tail docking leads to distress
	Castration allowed	
	Spacious free range area	

Discussion and conclusions

The objective of this study was to assess broiler and fattening pig farmers' willingness-to-convert to alternative production systems with higher levels of AW, and to explore farmer's perceptions of potential barriers to the adoption of these alternative systems. Alternative production systems were classified according to whether the changes that farmers were required to make to their current production system were reversible or irreversible. Reversible changes do not require large investments and mainly affect variable costs, therefore the conventional farming practice can be easily restored. In contrast, irreversible changes involve large investments, which limits the flexibility of farmers to revert to the conventional farm situation. In this regard, the results show that both broiler and fattening pig farmers were more willing to adopt systems requiring reversible changes compared to systems requiring irreversible changes, such as covered veranda and outdoor access.

Higher AW standards usually generate increased net costs (Spoolder et al., 2011; Gocsik et al., 2013). Many of the respondents were willing to convert to a system requiring reversible changes if they knew they could earn the same income as they did in the conventional production system, i.e., if the increased costs due to higher AW standards were compensated. However, the results also show that, on average, broiler and fattening pig farmers perceived that earning a price premium for products with higher levels of AW was quite uncertain and that the price premium was not sufficient to cover the extra costs. Furthermore, the results suggest that in the case of irreversible investments, farmers require a higher increase in their family income to reduce the payback period of the investment and thereby reduce the income risk.

The expert validation confirmed the results of the survey for both broiler and fattening pig farmers, with the exception of a few differences. Experts tended to estimate farmers’ willingness-to-convert as higher than the results of the survey suggested. For most statements, the experts had similar estimates about the percentage of farmers for whom the statement was relevant. A possible explanation for this is that the experts are likely to be regularly involved in discussions about the sectors, and therefore have a similar reference point.

The results of this study have implications for policy-making and for the design of future production systems aimed at increasing AW. To facilitate the transition to systems with higher AW standards, it is important to manage the (perceived) uncertainty of the market and price premiums. Uncertainty can be managed either by governmental policies or specific long-term agreements between supply chain parties. Van Huik and Bock (2007) also concluded that farmers’ reluctance is not caused by a negative attitude towards AW as such, but by the negative

consequences of switching to an alternative system, such as the need to invest in new systems and the unknown financial impact of standards. Animal welfare policies, therefore, need to offer a long-term perspective and require commitment from all stakeholders in the supply chain. An important first step is the further development of the middle-market segment

Table 4.7 Results of the survey, in terms of the perception of external factors and willingness-to-convert to an alternative system of a typical broiler farmer, and their representativeness at regional and national level according to expert opinion (estimates greater than the upper bound of the confidence interval shown in **bold**, estimates smaller than the lower bound of the confidence interval shown in *italic*)

	Survey			Proportion farmers in the area of Noord-Brabant and Limburg			Proportion of the farmers in the Netherlands		
	Proportion respondents	Lower bound 95% CI	Upper bound 95% CI	Expert 1	Expert 2	Expert 3	Expert 1	Expert 2	Expert 3
The typical broiler farmer									
Perception of external factors									
thinks that the availability of land for farm expansion is low.	55	34	76	*20*	50	**90**	*10*	50	**90**
thinks that the length of land acquisition is long.	67	47	87	*30*	50	**100**	*10*	50	**100**
thinks that getting a price premium for products with higher animal welfare standards is uncertain.	76	58	94	90	90	80	70	90	80
expects that the price premium for products with higher animal welfare standards does not fully cover the extra costs.	75	56	94	90	80	80	70	80	80
thinks that the costs of transition to an alternative system are high.	81	64	98	90	**100**	80	70	**100**	80
Willingness-to-convert to an alternative system									
is willing to implement *small changes* with regard to animal welfare compared to the conventional system if his family income is not affected (e.g,. a decreased stocking density of 38 kg/m^2, a longer growth period of 45 days).	47	22	72	50	**90**	70	**80**	**90**	70

Continued

Table 4.7 (Continued) Results of the survey, in terms of the perception of external factors and willingness-to-convert to an alternative system of a typical broiler farmer, and their representativeness at regional and national level according to expert opinion (estimates greater than the upper bound of the confidence interval shown in **bold**, estimates smaller than the lower bound of the confidence interval shown in *italic*)

	Survey			Proportion farmers in the area of Noord-Brabant and Limburg			Proportion of the farmers in the Netherlands		
	Proportion respondents	Lower bound 95% CI	Upper bound 95% CI	Expert 1	Expert 2	Expert 3	Expert 1	Expert 2	Expert 3
is willing to implement *somewhat larger changes* (i.e., reversible changes) with regard to animal welfare compared to the conventional system if his family income is not affected (e.g., a decreased stocking density of 27.5 kg/m^2, a longer growth period of 3 days, but no free-	47	22	72	50	**80**	50	**80**	**80**	50
is willing to implement *large changes* (i.e., irreversible changes) with regard to animal welfare compared to the conventional system if his family income is not affected (e.g., covered veranda, outdoor access).	15	0	34	20	**50**	20	**60**	**60**	20

Table 4.8 Results of the survey, in terms of the perception of external factors and willingness-to-convert to an alternative system of a typical fattening pig farmer, and their representativeness at regional and national level according to expert opinion (estimates greater than the upper bound of the confidence interval shown in **bold**, estimates smaller than the lower bound of the confidence interval shown in *italic*)

	Survey			Proportion farmers in the area of Noord-Brabant and Limburg				Proportion of the farmers in the Netherlands			
	Proportion respondents	Lower bound 95% CI	Upper bound 95% CI	Expert 1	Expert 2	Expert 3	Expert 4	Expert1	Expert 2	Expert 3	Expert 4
The typical fattening pig farmer											
Perception of external factors											
thinks that the availability of land for farm expansion is reasonable.	50	24	76	*20*	*20*	70	**80**	40	70	70	**80**
thinks that length of land acquisition is long.	60	34	86	80	80	70	*20*	80	50	70	*20*
thinks that getting a price premium for products with higher animal welfare standards is uncertain.	67	42	92	80	90	60	80	70	90	60	90
expects that the price premium for products with higher animal welfare standards does not fully cover the extra costs.	71	47	95	90	90	*20*	80	90	90	*20*	90
thinks that the costs of transaction to an alternative system are high.	67	41	93	70	90	*40*	90	60	90	*40*	90

Continued

Table 4.8 (Continued) Results of the survey, in terms of the perception of external factors and willingness-to-convert to an alternative system of a typical fattening pig farmer, and their representativeness at regional and national level according to expert opinion (estimates greater than the upper bound of the confidence interval shown in bold, estimates smaller than the lower bound of the confidence interval shown in *italic*)

	Survey			Proportion farmers in the area of Noord-Brabant and Limburg				Proportion of the farmers in the Netherlands			
	Proportion respondents	Lower bound 95% CI	Upper bound 95% CI	Expert 1	Expert 2	Expert 3	Expert 4	Expert1	Expert 2	Expert 3	Expert 4
Willingness-to-convert to an alternative system											
is willing to implement *small changes* with regard to animal welfare compared to the conventional system if his family income is not affected (e.g., a larger indoor space of 1.0 m^2, provision of wood and sturdy rope as enrichment material).	77	54	100	80	*30*	80	70	80	*30*	80	60
is willing to implement *somewhat larger changes* (i.e., reversible changes) with regard to animal welfare compared to the conventional system if his family income is not affected (e.g., provision of straw and roughage as enrichment material, large groups, but no free-range).	46	19	73	70	20	**80**	50	70	20	**80**	40
is willing to implement *large changes* (i.e., irreversible changes) with regard to animal welfare compared to the conventional system if his family income is not affected (e.g., free-range).	8	0	23	**60**	10	20	10	**40**	10	20	10

by including production systems that only require reversible changes to the farm. In addition to providing better conditions for farm animals, a middle-market segment also offers prospects for several parties in the supply chain. At farm level, these systems could be attractive because farmers have the flexibility to revert to the conventional system if their expectations are not met. The results in this study indicated that farmers were more willing to convert to a production system that required reversible changes. Furthermore, these systems enable farmers to produce with a relatively low increase in production costs compared to, for example, free-range systems. Consequently, retailers could supply consumers with these products at a relatively small price premium.

The economic viability of AW systems ultimately depends on consumers' willingness to pay for products with higher AW (Harvey and Hubbard, 2013). Studies have shown that consumer segments exist that are willing to pay a premium for products with higher AW standards (Kehlbacher et al., 2012; de Jonge, 2014). However, many farmers perceive the market for animal-friendly products as very small and expect that it will remain small in the future (van Huik and Bock, 2007).

The results of this study suggest that the current farm set-up can limit the adoption of alternative production systems. Although differences in farm set-up may exist across farms, a large part of broiler and pork meat production in the Netherlands comes from conventional production systems on medium-sized and large-sized farms. Hence, these farms have a large share in the level of AW in the country as a whole. The largest increase in overall AW can, thus, probably be achieved by implementing changes in these farms. Therefore, it is important to take into account the characteristics of these farms when designing market concepts.

Farmers are willing to adopt higher AW standards that require reversible changes to the farm as long as the extra costs are covered and these changes fit their current farm set-up. However, to implement irreversible investments, farmers require more certainty. Stakeholder collaboration aimed at the harmonization of supply and demand and the creation of favorable market conditions is essential for creating a more certain market environment that facilitates the uptake of production systems with higher levels of AW.

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References

Bennett, R., Larson, D. (1996). Contingent valuation of the perceived benefits of farm animal welfare legislation: An exploratory survey. Journal of Agricultural Economics, 47:224-235. DOI: 10.1111/j.1477-9552.1996.tb00686.x.

Bennett, R.M. (1997). Farm animal welfare and food policy. Food Policy, 22:281-288. DOI: http://dx.doi.org/10.1016/S0306-9192(97)00019-5.

De Buck, A.J., van Rijn, I., Röling, N.G., Wossink, G.A.A. (2001). Farmers' reasons for changing or not changing to more sustainable practices: an exploratory study of arable farming in the Netherlands. The Journal of Agricultural Education and Extension, 7:153-166. DOI: 10.1080/13892240108438817.

De Jonge, J. (2014). Personal communication. Wageningen University, Wageningen

De Lauwere, C., van Asseldonk, M., van 't Riet, J., de Hoop, J., ten Pierick, E. (2012). Understanding farmers' decisions with regard to animal welfare: The case of changing to group housing for pregnant sows. Livestock Science, 143:151-161. DOI: http://dx.doi.org/10.1016/j.livsci.2011.09.007.

Gocsik, É., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2013). Mid-term financial impact of animal welfare improvements in Dutch broiler production. Poultry Science, 92:3314-3329. DOI: 10.3382/ps.2013-03221.

Gocsik, E., Saatkamp, H.W., de Lauwere, C.C., Lansink, A.G.J.M. (2014a). A Conceptual approach for a quantitative economic analysis of farmers' decision-making regarding animal welfare. Journal of Agricultural and Environmental Ethics, 27:287-308. DOI: 10.1007/s10806-013-9464-9.

Gocsik, É., van der Lans, I.A., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2014b). Elicitation of preferences of Dutch broiler and pig farmers to support decision making on animal welfare. Working paper. Wageningen University.

Greiner, R., Gregg, D. (2011). Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia. Land Use Policy, 28:257-265. DOI: http://dx.doi.org/10.1016/j.landusepol.2010.06.006.

Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., Lien, G. (2004). Coping with risk in agriculture, 2nd ed. CABI, Wallingford.

Harvey, D., Hubbard, C. (2013). The supply chain's role in improving animal welfare. Animals, 3:767-785. DOI: 10.3390/ani3030767.

Immink, V.M., Reinders, M.J., van Tulder, R.J.M., van Trijp, J.C.M. (2013). The livestock sector and its stakeholders in the search to meet the animal welfare requirements of society. Journal on Chain and Network Science, 13:151-160. DOI: 10.3920/jcns2013.1005.

Kehlbacher, A., Bennett, R., Balcombe, K. (2012). Measuring the consumer benefits of improving farm animal welfare to inform welfare labelling. Food Policy, 37:627-633. DOI: 10.1016/j.foodpol.2012.07.002.

Koch, G., Elbers, A.R.W. (2006). Outdoor ranging of poultry: a major risk factor for the introduction and development of High-Pathogenicity Avian Influenza. NJAS-Wageningen Journal of Life Sciences, 54: 179-194. DOI: 10.1016/S1573-5214(06)80021-7.

Mitchell, R.C., Carson, R.T. (1989). Using Surveys to Value Public Goods: The contingent valuation method. Johns Hopkins University Press, Baltimore.

Oude Lansink, A., van den Berg, M., Huirne, R. (2003). Analysis of strategic planning of Dutch pig farmers using a multivariate probit model. Agricultural Systems, 78:73-84. DOI: 10.1016/S0308-521x(03)00034-9.

Spoolder, H., Bokma, M., Harvey, D., Keeling, L., Majewsky, E., de Roest, K., Schmid, O. (2011). EconWelfare findings, conclusions and recommendations concerning effective policy instruments in the route towards higher animal welfare in the EU. http://www.econwelfare.eu/publications/EconWelfareD0.5_Findings_conclusions_and_recommendations.pdf

Tuyttens, F.A.M., Struelens, E., van Gansbeke, S., Ampe, B. (2008). Factors influencing farmers' responses to welfare legislation: A case study of gestation sow housing in Flanders (Belgium). Livestock Science, 116:289-299. DOI: 10.1016/j.livsci.2007.10.013.

Van Huik, M.M., Bock, B.B. (2007). Attitudes of Dutch pig farmers towards animal welfare. British Food Journal, 109:879-890. DOI: 10.1108/00070700710835697.

Vanhonacker, F., Verbeke, W. (2014). Public and consumer policies for higher welfare food products: Challenges and opportunities. Journal of Agricultural and Environmental Ethics, 27:153-171. DOI: 10.1007/s10806-013-9479-2.

Witte, R.S., Witte, J.S. (2010). Statistics, 9th ed. John Wiley & Sons, Inc, NJ, USA.

Chapter 5

Mid-term financial impact of animal welfare improvements in Dutch broiler production

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Abstract

This study used a stochastic bioeconomic simulation model to simulate the business and financial risk of different broiler production systems over a five-year period. Simulation analysis was conducted using the @Risk add-in in MS Excel. To compare the impact of different production systems on economic feasibility, two cases were considered. The first case focused on the economic feasibility of a completely new system, whereas the second examined economic feasibilities when a farm switches from a conventional to an animal welfare-improving production system. A sensitivity analysis was conducted to assess the key drivers of economic feasibility and to reveal systematic differences across production systems. The study shows that economic feasibility of systems with improved animal welfare predominantly depends on the price that farmers receive. Moreover, the study demonstrates the importance of the level and variation of the price premium for improved welfare, particularly in the first five years after conversion. The economic feasibility of the production system increases with the level of welfare improvements for a sufficiently high price level for broiler meat and low volatility in producer prices. If this is not the case, however, risk attitudes of farmers become important as well as the use of potential risk management instruments.

Keywords: Animal welfare, Broiler production, Economic feasibility, Stochastic simulation

Introduction

In the Netherlands, broiler chickens are primarily kept in intensive conventional production systems. The sector operates in a highly competitive environment and is export oriented (van Huik and Bock, 2007; PVE, 2012). Therefore, competitive pricing and production efficiency are essential to keeping up with competitors. Production is primarily cost-price driven, and farms operate with a tight and volatile profit margin.

The welfare of animals kept in intensive production systems is increasingly becoming a subject of public concern. Consequently, the legal standards with regard to animal husbandry have been increased, and various new market concepts have been developed. These new developments require farmers to adjust their production systems and practices. However, animal welfare (AW) improvements in broiler production often lower productivity; in other words, they increase input costs, resulting in a higher cost-price (Verspecht et al., 2011). An increase in cost-price that is not matched with revenues can have significant effects on farm income and, in turn, on the livelihood of the family (Den Ouden, 1996; Barry and Ellinger, 2012; Kay et al., 2012).

Moreover, livestock farmers face various types of risk (Hardaker et al., 2004). Price risks caused by volatility of input and output prices are perceived as the most important source of risk among Dutch livestock farmers (Pennings and Smidts, 2000; Meuwissen et al., 2001). Although price volatility is a normal feature of agricultural markets, specific characteristics of individual markets can increase these price risks. In the Netherlands, consumers prefer to purchase certain cut-up parts, such as breasts, instead of a whole chicken (Bokkers and de Boer, 2009). Therefore, supermarkets mostly stock chicken breasts on the shelves, whereas other parts are processed by the food industry or exported. If such a phenomenon occurs for AW-friendly products, the increase in cost-price has to be transferred primarily to the price of the chicken breast, resulting in a disproportionately high price for that part (Ellen et al., 2012). Farmers' incomes are negatively affected if consumers are not willing to pay this price premium because their increased costs are not covered. Therefore, as many cut-up parts as possible should be charged with a price premium. Moreover, price risks can be more pronounced in the market for AW-friendly products. Because the market for AW products is still developing, changes in supply and demand could have more significant effects on prices than in the market for conventional products. Increased risk can severely threaten the continuity of the farm. Large investments often require a significant amount of external debt capital. In particular, the first few years after the investment - when liabilities are often large - are crucial in terms of continuity of the farm. Insufficient financial buffers during high-risk years may threaten the continuity of the farm. Therefore, an analysis of the financial consequences of AW improvement options must address the farm's capacity to survive the high-risk period; analysis simply based on average costs and returns is insufficient.

The existing literature used deterministic approaches to analyze the economic implications of various AW measures at the farm level. Verspecht et al. (2011) investigated the economic impact of decreasing stocking density on farm profitability. Seibert and Norwood (2011) studied the cost of hog production under alternative production systems, and Ellen et al. (2012) examined the costs for different broiler production systems based on Dutch private labels. All of these studies indicated that, in most cases, higher welfare standards entail higher production costs (SCAHAW, 2000). However, these studies did not analyze the effect of increased production costs on the continuity of the farm in the long run. That is, uncertainties surrounding key variables were not addressed, and the differences in volatility of the indicators used to compare production systems were ignored.

The aim of this study is to analyze the economic feasibility and risks of various AW measures on broiler farms over a five-year planning horizon. For this purpose, a stochastic simulation model was developed and the economic feasibility of different broiler production systems was compared.

The remainder of this paper is structured as follows. The next section presents an overview of the broiler production systems in the Netherlands and describes the methodology and data used in this paper. This section is followed by a description of the results. Finally, the paper concludes with comments.

Materials and methods

Overview of the Broiler Production Systems in the Netherlands

Production and marketing standards of broiler meat are established at the European Union (EU) level [Regulation (EC) No. 543/2008; Regulation (EC) No. 834/2007; Directive, 2007/43/EC]. The Dutch legislation recognizes six production systems similar to those defined by the EU guidelines, although the requirements are stricter than that of the EU level in some aspects (PPE, 2004). Table 5.1 presents an overview of the main characteristics and requirements of different production systems currently present in the Netherlands. Some of the production systems are based on the EU guidelines (conventional and organic), and some are specific to the Dutch market (Gildehoen, Volwaard, Puur en Eerlijk, and Kemper Mais-

Table 5.1 Characterization of production systems currently present in the Netherlands (Ellen et al., 2012)

Variable	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Type of chicken	Fast-growing	Slow-growing	Slow-growing	Slow-growing	-	Slow-growing
Length growth period (day)		49	56	56	63	>70
Weight at delivery (g)	2,200	2,150	2,300	2,300		-
Enrichment						>95% organic feed
Provision of grain	-	Twice a day	Optional	2 g/day from 2nd week	2 g/day from 3rd week	-
% Grain in feed	-	> 70% sustainable soy	Ca. 70%	> 70%	> 70%	-
Provision of straw	-	Yes	Yes	Yes	1 straw bale/ 1,000 animals	-
Stocking density						
kg/m^2	39 (42)	31	$31^{1)}$	$25^{1)}$	27.5	21
Chickens/m^2		15		12	$13^{2)}$	10
Outdoor access	No	No	Covered veranda	Covered veranda	Outdoor 1 m^2/chicken	Outdoor 4 m^2/chicken
Lighting regime						
Daylight	No	Yes	No	Yes	10 lux by 1,200 lux outside	Yes
Dark period	6 h/24 h, from which 4 h uninterrupted	6 h	6 h	8 h	Max. 8 h	>8 h
Flock size	-	-	-	-	Max. 5000 animals	Max. 4800 animals
Barn size	-	-	-	-	-	Max. 1600 m^2

[1] Included covered veranda.

[2] Fifteen chickens/m^2 in the first 3 week.

Scharrelkip). The conventional system uses a fast-growing breed, chickens are delivered with a final weight of around 2,200 g. Birds are kept with a maximum stocking density of 39 kg per m^2 (or 42 kg per m^2, providing a maximum mortality rate set in the regulation), and an uninterrupted dark period of 4 h is required. Despite minor differences within the EU countries, the conventional system resembles the industrial type of production broilers in other EU countries (Roex and Miele, 2005; van Horne and Achterbosch, 2008). Outside the EU, Switzerland has higher minimum legislative standards for broiler production. The rest of the world sets lower minimum legislative standards for broiler production than the EU or provides only voluntary guidelines for the industry (e.g., the United States). The requirements of the Dutch market concepts are designed in line with the legislative standards but often combine the criteria of the independent production systems defined by legislation. All the alternative systems (Gildehoen, Volwaard, Puur en Eerlijk, and Kemper Mais-Scharrelkip) specific to the national market uses slow-growing breeds. The length of the growth period varies between 49 and 63 days, and birds are delivered with a final weight ranging from 2,150 to 2,400 g. The rate of the stocking density varies between 25 and 31 kg per m^2. Enrichment, such as straw bales and grain, is provided for the chickens and feed has at least a grain content of 70%. A covered veranda (an indoor free-range area) is available in the Volwaard and Puur en Eerlijk systems. The Kemper-Mais Scharrelkip system is facilitated with an outdoor range of 1 m^2 per chicken, and the flock size is restricted to a maximum of 5,000 chickens. In alternative systems, the uninterrupted dark period is between 6 and 8 h. Alternative systems that are specific to national markets are also common in other countries, such as in France (e.g., Label Rouge) or in the United Kingdom. Although the Dutch national standards for organic production is stricter than the EU standards, the EU standards were included in the analysis to enable a better comparison with other EU countries. According to the EU standards, organic production uses a slow-growing breed and chickens are kept for a minimum of 70 days. At least 95% of the feed comes from organic sources. A maximum of 21 kg chicken per m^2 shall be kept, that is, 10 chickens per m^2. Chickens are provided with an outdoor range of 4 m^2 per chicken. The flock size is restricted to 4,800 chickens per barn and the area of the farm cannot exceed 1,600 m^2. The dark period is uninterrupted for at least 8 h per day. Production systems that go beyond the minimum AW standards in certain aspects but that do not comply with organic standards are usually referred to as a middle-market segment (Dutch: "tussensegment"). These systems are intended to bridge the gap between conventional and organic systems and to meet a heterogenic consumer demand in terms of AW (Jonge and van Trijp, 2013). Still, most of the broiler meat (approximately 97%) is produced in conventional systems according to the minimum standards (Ellen et al., 2012).

A Measure for Economic Feasibility Under Risk

In this study, economic feasibility is defined similar to the term economic sustainability by Hansen and Jones (1996). If time to failure, T_F, is a random variable with a cumulative probability distribution, F_{TF}, then economic feasibility, E, for the period (0, T) is defined as

$$E(T) = 1 - F_{TF}(T). \tag{5.1}$$

Economic feasibility can be estimated by the simulated relative frequency of surviving realizations, or

$$\hat{E}(T) = \frac{n(T)}{N} \tag{5.2}$$

where $n(T)$ is the number of nonfailures at time T and N is the total number of iterations used in the simulation. In this study, each scenario was repeated 5,000 times using Latin Hypercube sampling in the @Risk software environment (Palisade Corporation, Ithaca, NY). System failure can be defined in various ways. Lien et al. (2007) identified failure when the farm owner's equity drops below zero, indicating technical insolvency. Hansen and Jones (1996) used two criteria of farm failure: a debt-to-equity ratio (leverage) exceeding 2.0 or a negative net present value of future cash flows. In the present study, a negative cumulative capital debt repayment margin (CDRM; net farm income + depreciation + nonfarm income – family withdrawals – tax expenses – scheduled principal payments) at the end of year 5 (CDRM-5) indicates system failure. This criterion is chosen because it reflects the ability of the farm to maintain its production on a cash-flow basis without drawing on its financial reserves. Capital debt repayment margin measures the amount of money that remains after all of the operating expenses, taxes, family living costs, and debt payments have been paid (Barry and Ellinger, 2012). A negative CDRM-5 implies that the farm is not able to fulfill all of its financial obligations. Although the CDRM can be negative in one or several years between year 1 and 5, this value is not considered a failure because liquidity issues can be managed in the short run (for example, by decreasing the level of family withdrawals). However, farm operations cannot be sustained if problems of this kind exist in the long term. A relevant timeframe of economic sustainability and feasibility studies is usually 5 to 20 year (Hansen and Jones, 1996). In this study, a five-year period was selected because it was judged to be long enough to allow the detection of important threats to the continuity of the farm.

The Stochastic Bioeconomic Simulation Model

Stochastic simulation models are widely used to analyze the effect of uncertainty inherent in agricultural production; for example, for investigating the economic feasibility of biogas plants (Gebrezgabher et al., 2012) and evaluating technology investments in the dairy business, such as a robotic milking system and precision dairy farming (Hyde and Engel, 2002; Bewley et al., 2010). Lien (2003) examined the financial feasibility of different investment and management strategies of a Norwegian dairy farm through stochastic budgeting. Lien et al. (2007) evaluated different crop farming systems in terms of financial survival and stochastic risk efficiency. Although stochastic simulation models do not give the exact answers, they support decision making by providing information on the relative consequences of different options. Hence, this study used a stochastic bioeconomic simulation model to simulate the business and financial risk on the technical and economic performance of different broiler production systems over a five-year time horizon. Simulations were conducted using @Risk, an add-in in MS Excel (Microsoft Corporation, Redmond, WA).

Technical Inputs

Production uncertainty was incorporated by defining probability distributions for key technical variables, such as weight at delivery, daily growth, feed conversion ratio, and mortality (Table 5.2). The length of the growth period was considered a deterministic variable in the model because some concepts define its minimum. However, in practice, the period may vary somewhat depending on daily growth and weight at delivery. Information on the average technical performance of various production systems was gathered from the literature (KWIN-V, 2011; Ellen et al., 2012). However, information on the variation of technical variables for each system was not available in the literature. The Agricultural Economics Research Institute (LEI) provided a data set on technical variables of conventional production systems to estimate the variation of the variables. The relative variance of each variable (measured by the CV; SD/ mean) in a conventional system was calculated based on this confidential data set. To calculate absolute deviations, the average values gathered from the literature and the calculated relative variances were used. To estimate the absolute deviations of the variables in alternative systems, the same relative variances were assumed as in a conventional system. Based on the means and SD presented in Table 5.2, normal distributions were defined for each variable and then inserted in the model. Besides technical inputs, Table 5.2 includes those system characteristics

Table 5.2 Main technical variables by selected production systems

Variable	Unit	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Enrichment							
Provision of grain	g/day	-	2[1]	2[1]	2 from week 2	2 from week 3	-
% Grain in feed	%	-	Ca. 70[1]	Ca. 70[1]	Ca. 70[1]	Ca. 70[1]	-
Provision of straw	Per 1,000 chickens	-	1 straw bale	1 straw bale	1 straw bale	1 straw bale	-
Stocking density at start	Chickens/m^2	19.8	14.7	16.9	13.6	13.4	8.3
Length growth period	Day[2]	40[3]	49[3]	56[3]	56[3]	63[3]	70[3]
Weight at delivery	Mean (g)	2,200[3]	2,150[3]	2,300[3]	2,300[3]	2,400[4]	2,600[3]
	SD (g)	110[5]	107.5[5]	115[5]	115[5]	120[5]	130[5]
	CV (g)	0.05[6]	0.05[6]	0.05[6]	0.05[6]	0.05[6]	0.05[6]
Daily growth	Mean (g)	55.00[7]	44[5]	41[5]	41[5]	38[5]	37[5]
	SD (g)	1.65[5]	1.32[5]	1.23[5]	1.23[5]	1.13[5]	1.11[5]
	CV (g)	0.03[5]	0.03[5]	0.03[5]	0.03[5]	0.03[5]	0.03[5]
Feed conversion ratio	Mean (g of feed/g of weight)	1.69[7]	1.94[3]	2.09[3]	2.09[3]	2.25[4]	2.60[3]
	SD (g of feed/g of weight)	0.034[5]	0.039[5]	0.042[5]	0.042[5]	0.045[5]	0.052[5]
	CV (g of feed/g of weight)	0.02[6]	0.02[6]	0.02[6]	0.02[6]	0.02[6]	0.02[6]

Continued

Table 5.2 (Continued) Main technical variables by selected production systems

Variable	Unit	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Mortality	Mean (%)	3.70[7]	2.50[3]	2.50[3]	2.50[3]	2.80[3]	2.80[3]
	SD (%)	1.073[5]	0.725[5]	0.725[5]	0.725[5]	0.812[5]	0.812[5]
	CV (%)	0.29[6]	0.29[6]	0.29[6]	0.29[3]	0.29[6]	0.29[6]

[1] Own adjustments: the quantity of grains and straw provided for chickens is assumed to be similar across middle-market systems; no difference assumed in feed across middle-market systems although in practice the feed ingredients differ.

[2] Deterministic.

[3] Ellen et al., 2012

[4] Estimation based on expert opinion.

[5] Own calculation.

[6] Own estimation based on LEI data.

[7] KWIN-V, 2011

from Table 5.1 that needed to be translated into model inputs (enrichment and stocking density).

Prices

Returns are primarily determined by the producer price, whereas the main drivers of costs are feed costs and the price of one-day-old chicks (Castellini et al., 2012; Ellen et al., 2012). Producer prices, feed prices, and prices of one-day-old chicks were simulated over the five-year planning horizon using a geometric random walk (GRW) model. The reason for using a random walk model is that most economic time series follow a stochastic trend (Nelson and Plosser, 1982). The GRW model is a strictly positive stochastic process whose log returns (that is, differences in log prices), follow a Gaussian white noise. The equation for the GRW is written as follows (Fabozzi and Markowitz, 2011):

$$\ln\left(\frac{P_{t+i}}{P_t}\right) = \mu + \sigma \cdot \varepsilon_t \qquad \textbf{5.3}$$

where P_t is the price at time t, P_{t+i} is the price at time $t+i$, ε_t is an independent and identically distributed standard normal random variable [in other words, $\varepsilon_t \sim \text{IID N}(0,1)$], and μ and σ are constant.

Producer prices, feed prices, and one-day-old chick prices were assumed to not evolve independently. Therefore, the prices were simulated as correlated random walks and not independent random walks as implied by equation [5.3]. The correlated GRW model suggested that log returns are jointly normally distributed. That is, the error terms were correlated random variables with mean zero and a given covariance structure estimated based on the correlation between log returns. Correlations were calculated between

$$\ln\left(\frac{P_{t+i}^{(1)}}{P_t^{(1)}}\right) \text{and} \ln\left(\frac{P_{t+i}^{(2)}}{P_t^{(2)}}\right) \text{and} \ln\left(\frac{P_{t+i}^{(3)}}{P_t^{(3)}}\right) \qquad \textbf{5.4}$$

where superscripts (1), (2), and (3) correspond to producer price, feed price, and the price of day-old chicks, respectively. Correlation between $\ln\left(\frac{P_{t+i}^{(1)}}{P_t^{(1)}}\right)$ and $\ln\left(\frac{P_{t+i}^{(2)}}{P_t^{(2)}}\right)$ was 0.443 (P = 0.034), between $\ln\left(\frac{P_{t+i}^{(1)}}{P_t^{(1)}}\right)$ and $\ln\left(\frac{P_{t+i}^{(3)}}{P_t^{(3)}}\right)$ was 0.286 (P = 0.493), and $\ln\left(\frac{P_{t+i}^{(2)}}{P_t^{(2)}}\right)$ and $\ln\left(\frac{P_{t+i}^{(3)}}{P_t^{(3)}}\right)$ was 0.381 (P = 0.352). For the simulation of future prices, the closed-form expression for price P_t was applied (Fabozzi and Markowitz, 2011):

$$P_t = P_0 \cdot e^{\left(\mu - \frac{1}{2}\sigma^2\right)\cdot t + \sigma\sqrt{t}\cdot\varepsilon_t} \qquad \textbf{5.5}$$

where ε_t is a multivariate normal random variable. The price at the next period is a multiple of a random term and the price from the previous period. The model assumes that uncertainty increases with time because the volatility of the process grows with the square root of the elapsed amount of time. To simulate future prices, the two parameters μ and σ were estimated for the model. Given a historical series of prices, the parameters were estimated in three steps (Fabozzi and Markowitz, 2011).

1. Compute $\ln\left(\frac{P_{t+i}}{P_t}\right)$ for each time period t, t=0, ..., T-1.
2. Estimate the volatility of the GRW, σ, as the SD of all $\ln\left(\frac{P_{t+i}}{P_t}\right)$.
3. Estimate the drift of the GRW, μ, as the average of all $\ln\left(\frac{P_{t+i}}{P_t}\right)$, plus one-half of the SD.

Data were available for estimating parameters of the conventional production system. However, given a lack of historical data of the alternative systems, parameters were determined based on expert opinions and the literature (Ellen et al., 2012). Parameters for conventional systems were estimated based on a series of annual producer prices for the period 1988 to 2011, a series of annual feed prices for the period 1988 to 2011, and a series of annual one-day-old chick prices for the period 2003 to 2011 (LEI, 2012). Each time series was adjusted for inflation by dividing it by the annual consumer price index (CBS, 2012). The volatility was estimated as the SD of all $\ln\left(\frac{P_{t+i}}{P_t}\right)$. The SD of logarithmic returns (σ) in alternative systems was assumed to be the same as in a conventional system. The drift (μ) component is an indication of the trend in the time series and consists of the effect of several external factors, such as technological developments in a sector and disease outbreaks, which influence prices. By including an estimate for the drift based on historical data, future prices were implicitly assumed to be determined by the same external factors as in the past. Because this assumption is highly unlikely, future prices were assumed to remain at their current level for the forecast period, in other words, zero growth in prices. Initial prices for conventional production, P_0, were estimated as the average of the real prices from 2007 to 2011 (LEI, 2012). In alternative systems, different inputs are used, such as a slower growing breed, feed with higher grain content, or organic feed, also making input prices different. Moreover, products from alternative systems are sold at a price premium. Data were lacking on the price premiums that producers receive to produce according to higher AW standards. Consumer prices were used as a basis to derive price premiums because only these prices can be observed. However, lack of information on margins through the chain hampered the proper estimation of producer price premiums from the consumer price. First, an average consumer price per kilogram of carcass by each product concept was determined. In the Netherlands, broiler meat is mostly sold as cut-up chicken parts (92% in 2011) instead of the whole chicken (PVE, 2012). Therefore, an average price was calculated based on the prices of different parts. Consumer prices of natural cut-up pieces from two Dutch supermarket chains were collected in the beginning of 2013 (C1000 and Albert Heijn). Breast fillet and legs are usually sold at a price premium, unlike wings, which are usually sold as conventional products. The total quantity of breasts and legs produced in alternative systems were assumed sold at the indicated price premium; however, the exact proportion actually sold at a price premium was unknown. Carcass yields of fast-growing and slower-growing breeds were assumed to be the same, or 68.5% (van Horne et al., 2003). Cut-up yields varied depending on breed and production system and whether the chickens have access to a covered veranda (van Horne et al., 2003). Given the lack of information on systems with outdoor access and organic systems, the carcass and cut-up yields were assumed to be the same as those in systems with a covered veranda. Table 5.3 presents the calculated average consumer prices and price premiums by production system. Producer prices for alternative systems were calculated by assuming that producers' percentage price premium was the same as the consumer percentage price premium (Table 5.4). Table 5.4 summarizes the parameters for stochastic price simulations.

Variable and Fixed Costs

Inputs for calculate variable and fixed costs in different production systems were collected from various data sources, such as Quantitative Information Animal Husbandry 2011/2012 (KWIN-V, 2011), scientific articles, technical reports, and expert consultations. Table 5.5 summarizes the main variable costs. Note that technical performance and some variable costs were likely to correlate (for example, higher mortality is likely positively related with health costs). Therefore, in principle, these variable costs should be modeled as stochastic variables. However, because they represent only a small proportion of total costs (approximately 3%, and the main cost drivers were feed costs and the purchase of one-day-old chicks), they were treated as deterministic variables (Bokkers and de Boer, 2009). For systems using a slow-growing breed, the cost of health care was estimated at 80% of that of the fast-growing breed (because the slow-growing breed is more robust; van Horne et al., 2003). In alternative systems, bedding cost was higher than in conventional systems depending on the quantity of grains and

Table 5.3 Average consumer price and price premium by production systems (prices excluding value-added tax)

Item	Conventional		Gildehoen		Volwaard, Puur en Eerlijk		Kemper- Mais Scharrelkip		Organic	
	Cut-up parts yield (%)	Consumer price (€/kg)	Cut-up parts yield (%)	Consumer price (€/kg)	Cut-up parts yield (%)	Consumer price (€/kg)	Cut-up parts yield (%)	Consumer price (€/kg)	Cut-up parts yield (%)	Consumer price (€/kg)
Breast fillet	26.6	7.66	25.6	8.47	25.7	10.27	25.7	13.19	25.7	23.49
Legs	36.2	3.97	36.0	5.64	35.9	5.65	35.9	7.25	35.9	10.92
Wings	11.0	4.14	11.7	4.14	11.7	4.14	11.7	4.14	11.7	4.14
Rest	26.2	0.00	26.7	0.00	26.7	0.00	26.7	0.00	26.7	0.00
Average consumer price (€/kg of body weight)	2.69		3.21		3.53		4.44		7.15	
Average consumer price (€/kg of carcass)	3.93		4.68		5.15		6.48		10.44	
Price premium compared with conventional (%)	0		19		31		65		166	

Table 5.4 Estimated parameters for stochastic prices

Variable[1]	Conventional	Gildehoen	Volwaard, Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Producer price					
P_0 (€/kg)	0.794	0.944[2]	1.040[2]	1.310[2]	2.112[2]
σ	0.123	0.123	0.123	0.123	0.123
Feed price					
P_0 (€/100 kg)	31.839	30.883[3]	30.883[3]	30.883[3]	45.211[3]
σ	0.085	0.085	0.085	0.085	0.085
Day-old chick price					
P_0 (€/piece)	0.302	0.320[3]	0.320[3]	0.320[3]	0.438[3]
σ	0.036	0.036	0.036	0.036	0.036

[1] P_0 = initial price. σ = SD of logarithmic returns.

[2] Own calculation: conventional price is increased with corresponding price premium from Table 5.3.

[3] Estimation based on Ellen et al. (2012).

Table 5.5 Variable costs by production system (€ per bird)[1]

Variable[1]	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Health care	0.045	0.036	0.036	0.036	0.036	0.120
Electricity	0.023	0.023	0.023	0.023	0.023	0.012
Heating	0.045	0.045	0.068	0.068	0.068	0.090
Water	0.008	0.008	0.008	0.008	0.008	0.016
Bedding	0.008	0.028	0.030	0.028	0.026	0.040
Catching and loading	0.039	0.039	0.039	0.039	0.039	0.039
General costs and manure disposal	0.029	0.029	0.029	0.029	0.029	0.005
Labor hired	32.25	32.25	32.25	32.25	32.25	32.25
Control levies organic	0.045	-	-	-	-	654

[1] Except for €/hour for costs of hired labor and €/year for control levies organic.

straw provided. In case the production system is facilitated with covered veranda or with outdoor access, heating costs were increased by 50% (even more in organic systems; van Horne et al., 2003). For organic farms, water and heating costs were doubled, electricity costs were halved, and the cost of a vaccination against coccidiosis was included in health care costs (Vermeij, 2004). The independent organization SKAL in the Netherlands audits organic systems. The annual fee for the audit was €654 (SKAL-Tarievenblad, 2012). For organic systems, demand for organic poultry manure was assumed to be sufficiently high; therefore, the cost of manure removal was assumed to be zero (Bokkers and de Boer, 2009). Depreciation, interest, and maintenance for investment costs of buildings and equipment were calculated as fixed costs. For land, interest and maintenance costs (as land serves as an outdoor run for chickens) were calculated. For production systems that allow large-scale production, including conventional, Gildehoen, Volwaard, and Puur en Eerlijk, feed was assumed to be purchased in bulk and a discount of €3.5/100 kg of feed was assumed (KWIN-V, 2011). Depreciation was 4% on buildings and 8% on equipment. Calculated interest was 2.5% on land, 5% on average invested capital in buildings and equipment, and 6% on average invested capital in livestock. Organic systems can benefit from an interest rate lower than conventional systems ("green interest"). Therefore, a 4% interest was assumed on the average invested capital in fixed assets; in other words, buildings and equipment (Vermeij and van Horne, 2008). Replacement value per unit of investment in buildings, inventory, and land was assumed equal for all production systems (van Horne et al., 2003; Vermeij, 2004; KWIN-V, 2011; LEI and CBS, 2011). For organic systems, the replacement value of inventory was lower because of the use of natural ventilation in the barns and the lower stocking density. Fewer drinkers and feeders were needed than in a conventional system, and alarm installations and emergency generator were not required (Vermeij and van Horne, 2008). The farmer's own labor was also considered a fixed cost.

Interest Rates

The annual short-term and long-term loan interest rates were assumed fixed over the time horizon. For an estimation of these interest rates, the average of the 3-month EURIBOR for the period 2007 to 2012, or 2.15%, and the average of the 10-year Dutch government bond yield for the same period, or 3.35%, were used. A 0.2% risk premium was added to these calculated average interest rates, resulting in short-term (2.35%) and long-term loan interest rates (3.55%). As previously stated, organic producers can benefit from a lower interest rate to finance long-term investments. For organic farms, a 1% lower rate interest rate was assumed for long-term loans.

Income Tax

In the Netherlands, the most common business forms in agricultural production were the sole proprietorship and partnerships (van der Veen et al., 2007). Consequently, the main tax system for agricultural producers was the income tax. Income tax was calculated based on progressive tax brackets (including social security contributions; see Figure 5A.1 in Appendix 5A). To calculate income tax, a few assumptions were made about the farm situation because different tax facilities apply in different situations. The farm was assumed to operate as a sole proprietorship with a farmer (45 year old) working on the farm. The spouse worked outside the farm and his/her income was taxed separately. The main tax rules that apply in this farm situation in 2012 are summarized below. The Dutch system offers some favorable tax facilities for the assessment of income, such as averaging and loss transfer. Application of the income averaging facility is beneficial in case of highly volatile incomes. However, no tax was refunded if the difference between the paid tax and the recalculated tax was smaller than €545. This high threshold limits the relevance of this facility and was not considered in the model. The capital loss transfer allows agricultural entrepreneurs to carry over their loss to reduce the fiscal profit (consequently, the taxable income) in any of the three preceding years or in the next nine years. Moreover, self-employed farmers were entitled to the self-employed persons' tax allowance, which was a fixed amount of €7,280 deducted from the fiscal profit, but the amount deducted could not exceed the fiscal profit. Tax facilities existed to encourage investments, which were either general or related to the environment. According to the general investment deduction rule, the farmer could claim a deduction against the fiscal profit provided that an amount between €2,300 and €306,931 was invested in qualifying assets, such as buildings and equipment but not land, and the assets were put into operation. Moreover, several incentives facilitate investments on farms that bring environmental benefits and result in a significant improvement with regard to AW. For example, farmers investing in qualifying assets are able to reduce fiscal profits by up to 40% of the total amount of investment. The arbitrary depreciation rule allows certain assets to depreciate at an accelerated pace that the farmer can freely choose. Only the general investment deduction rule will be applied in the tax calculation because deciding on whether an investment qualifies for the last two facilities requires its evaluation based on several criteria that are out of the scope of this study.

In addition to the facilities that allow for reducing the taxable income, other tax relief strategies exist. First, the general tax credit of €2,033 applies to anyone living in the Netherlands. Second, the labor tax credit applies to self-employed individuals who receive profits from an enterprise. The level of the labor tax credit depends on the level of income and age but may not exceed €1,611 and the amount of tax due.

Sensitivity Analysis

A sensitivity analysis was conducted to assess the key drivers of the CDRM and to reveal systematic differences between production systems. @Risk uses multivariate stepwise regression to perform the sensitivity analysis. A multiple regression analysis was run for each iteration with the output of interest as the dependent variable and the simulated values of each stochastic variable as independent variables.

Description of Cases Investigated

To compare the effect of different production systems on economic feasibility, two cases were considered. Case 1 focused on the economic feasibility of a completely new system. Case 2 examined the economic feasibilities when the farm switches from a conventional to an alternative AW-improving production system. In the initial analysis, cases with default inputs were investigated. Given the uncertainty with regard to certain input values (for example, price premiums), a sensitivity analysis was carried out and various scenarios were investigated after the analysis of default situations. Cases 1 and 2 are described here.

Case 1: New Farms

In this case, calculations for Conventional, Gildehoen, Volwaard, and Puur en Eerlijk systems were based on a farm with 60,000 animal places in two barns. Calculations for the Kemper-Mais Scharrelkip system were based on a farm with 15,000 animal places in three barns because, in the Netherlands, free-range production currently operates on a small scale and the flock size limit is 5,000 chickens. Calculations for organic system were based on a farm with 14,400 animal places in three barns given limits on flock size and total usable floor area. The available labor on the farm was assumed to be one full-time equivalent, which corresponds to approximately 2,300 labor hours per year (KWIN-V, 2011). If the total labor requirement of the system exceeded the available labor on the farm, the farmer hired additional labor. The debt-to-equity ratio at the start of the simulation period was 70/30. Nonfarm income was assumed fixed every year in the simulation period at €11,045, which represented the average nonfarm income over the last 10 year in the Netherlands (LEI, 2012). Annual withdrawals for family living were arbitrarily set at €20,000 on the basis of the income norm for a person living alone in the Netherlands, or €20,630 per year (KWIN-V, 2011). Loan payments were calculated assuming an annuity loan with a 0% down payment over a 20-year period with an interest rate of 3.55%.

Case 2: Transition from Conventional to Alternative Systems

In this case, the conventional farm (with 60,000 animal places in 2 barns) was assumed to have been built 15 year ago and was financed by 70% debt and 30% equity capital. Annual loan payments were calculated as in case 1. The debt-to-equity ratio at the beginning of year 16 was 60/40. The economic life span of farm buildings is 25 year; hence, 10 year of depreciation remained for the buildings. However, the economic lifespan of inventory is 12.5 year and no replacement was assumed after that period; hence, by the 16th year, the inventory was fully depreciated. Therefore, interest and depreciation were not calculated for this inventory, but because the inventory was assumed still in use the maintenance costs were accounted for. No additional barn area was assumed to be built, although the farm could be expanded with a covered veranda and land could be bought to give the chickens outdoor access. The maximum number of chickens that can be kept in a barn is limited to 5,000 in the Kemper-Mais Scharrelkip system and to 4,800 in an organic system. Because the existing farm had two barns, 10,000 chickens could be kept on the farm when switching to Kemper-Mais Scharrelkip production and 9,600 chickens when switching to organic production. New investments were financed by equity if the investment amount did not exceed €15,000. Investments exceeding €15,000 were financed by an annuity loan with a 0% down payment and 3.55% interest. For an investment larger than €15,000 but lower than €50,000, the term of the loan was five year. If the investment was larger than €50,000 but lower than €150,000, the term of the loan was 10 year. Investments larger than €150,000 were financed by a 20-year loan.

Results

Default Situation

In the default situation, the farmer was assumed to receive higher prices for more AW-friendly products than for conventional products, and these price premiums were certain.

Case 1: New Farms

Table 5.6 shows the basic economic and technical results with a focus on the first production year for all production systems.

Table 5.6 Summary of output (case 1; €, except otherwise indicated)

	Conventional		Gildehoen		Volwaard		Puur en Eerlijk		Kemper-Mais Scharrelkip		Organic	
Item	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Year 1 results												
Number of animal places	60,000		60,000		60,000		60,000		15,000		14,400	
Delivered animals per year (no.)	421,794	4,699	361,907	2,690	323,523	2,406	323,523	2,405	72,900	609	63,860	534
Delivered animals per year (kg)	927,959	47,797	778,096	39,257	744,102	37,659	744,102	37,606	174,960	8,864	166,035	8,399
Labor per production unit (h/chicken)	0.004		0.006		0.007		0.007		0.010		0.021	
Total revenues	736,804	98,699	734,535	98,113	773,854	103,238	773,919	103,752	229,192	30,574	350,681	46,941
Total variable costs	670,065	51,544	614,881	47,387	615,159	49,158	614,593	49,890	164,799	12,732	264,881	20,463
Feed cost	444,398	48,949	413,296	45,095	425,861	47,022	425,925	47,656	121,564	12,207	195,175	19,762
Other variable costs	225,667	5,399	201,585	4,713	189,298	4,298	188,668	4,334	43,681	1,033	69,706	1,303
Total fixed costs	155,392	4,833	193,058	6,719	185,274	6,331	215,974	7,860	101,613	2,040	107,614	2,050
Labor own	58,725		58,725		58,725		58,725		58,725		58,725	
Depreciation	43,879	2,194	60,735	3,036	56,887	2,845	70,688	3,535	18,693	1,153	20,288	982
Maintenance	10,970	548	15,184	759	14,222	711	17,672	884	4,673	549	5,072	246
Interest buildings, equipment, land	41,818	2,091	58,414	2,922	55,440	2,773	68,890	3,445	19,522	576	23,529	822
Net return to labor and management	−29,927	83,236	−14,679	83,105	32,145	86,900	2,078	85,895	21,058	25,704	36,911	39,064
Net farm income	−16,260	83,389	8,456	83,286	54,104	87,062	30,802	86,078	28,452	25,748	45,845	39,108
Nonfarm income net of expenses	11,045		11,045		11,045		11,045		11,045		11,045	
Depreciation	43,879	2,194	60,735	3,036	56,887	2,845	70,688	3,535	18,693	1,153	20,288	982
Tax expense	8,604	18,813	13,170	23,378	25,644	32,338	18,778	28,150	6,544	8,231	14,097	15,201
Withdrawals for family living	20,000		20,000		20,000		20,000		20,000		20,000	
Principal payments	20,587		28,758		27,293		33,915		10,479		18,798	
Capital debt repayment margin at the end of the year 1	−10,569	68,734	18,307	65,036	49,098	58,065	39,842	62,725	21,116	18,643	24,283	25,126
Cumulative results at the end of year 5												
Cumulative capital debt repayment margin at the end of year 5	−62,657	256,576	82,205	237,977	232,699	217,275	186,756	231,863	93,787	65,491	156,141	86,784
Probability of positive capital debt repayment margin at the end of year 5 (%)	43		65		86		79		92		97	

Figure 5.1 presents the cumulative distribution functions (CDF) of the CDRM-5. Because the vertical axis represents the probability, all values ranged from 0 to 1. The horizontal axis depicts the values for CDRM-5.

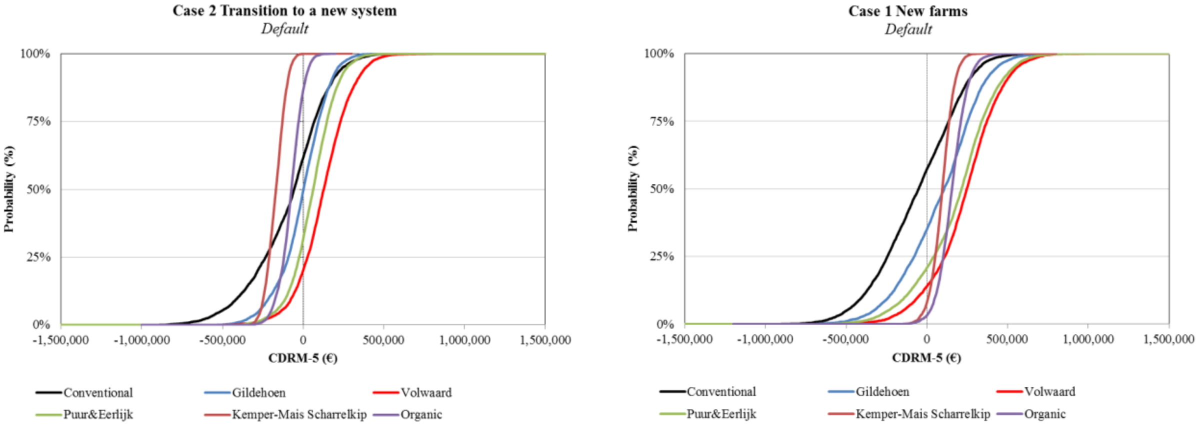

Figure 5.1 Simulated cumulative distribution functions of the cumulative capital debt repayment margin at the end of year 5 (CDRM-5) for case 1 (new farms) and case 2 (transition from conventional to alternative systems) in the default situation.

The CDF gives the probability of having a CDRM-5 less than or equal to a given value on the x-axis. According to our definition, a system is economically feasible if the CDRM-5 is greater than or equal to zero. The figure shows that alternative systems were moreeconomically feasible than conventional systems. For the Kemper-Mais Scharrelkip and organic systems, the likelihood of a positive CDRM-5 was approximately 92 and 97%, respectively. The likelihood of the economic feasibility of the Gildehoen, Puur en Eerlijk, and Volwaard systems were 65, 79, and 86%, respectively. The likelihood of a positive CDRM-5 for the conventional system was approximately 43%, which implies that a 57% chance existed of not being able to fulfill all of its financial obligations at the end of year 5. Therefore, a need still exists for a financial buffer after year 5. The variation of CDRM-5 was similar in all systems except for Kemper-Mais Scharrelkip and organic, which are indicated by the steeper curves. This phenomenon could be explained by the assumption made regarding the parameters of the stochastic prices. In the Kemper-Mais Scharrelkip and organic systems, the same volatility in log returns as in conventional systems was associated with a higher price level. Moreover, these systems were assumed to produce at a small scale, leading to their relatively lower variation.

Case 2: Transition from Conventional to Alternative Systems

The economic feasibility of continuing with production in the conventional system after year 15 was slightly worse than that of a new system. In this case, the likelihood of a negative CDRM-5 was approximately 62%, given that inventory was fully depreciated by year 16 but was assumed to be still in use. Therefore, depreciation costs and calculated interests decrease and, consequently, net farm income increased on average. Further, in case 2, the debt level was lower than in case 1, indicating a lower interest expense. Therefore, the tax shield on depreciation and interest decreased, thereby reducing the amount of cash that remained on the farm. If the farm converted to a new system, fewer chickens could be kept there than previously because of the stocking density requirements. Farm revenues and, in turn, the CDRM-5 were reduced. Therefore, although the CDF of Volwaard and Puur en Eerlijk were slightly shifted to the left, these systems were still highly feasible. The likelihood of a negative CDRM-5 for the Gildehoen system increased from 35% (in case 1) to 49%. The effect on the economic feasibility of the Kemper-Mais Scharrelkip and the organic system was higher because only 10,000 chickens per round could be kept on the farm in the Kemper-Mais Scharrelkip system and only 9,600 in the organic system, and principal and interest payments still had to be paid for a building with 60,000 animal places (in conventional production). The economic feasibility of the Kemper-Mais Scharrelkip system declined to zero, whereas that of the organic system was now 25%.

Sensitivity Analysis

Table 5.7 presents the β coefficients of the multivariate regression analysis of the stochastic variables on the CDRM after year 1 (CDRM-1) for case 1 and case 2. The β coefficients refer to the number of SD the CDRM-1 changes given a 1 SD change in input, all other variables held constant. A parameter value of 0 indicated that no significant relationship existed between input and output, whereas a parameter value of 1 or –1 indicated a 1 or –1 SD change in the output for a 1 SD change in input.

The results show that CDRM-1 was most responsive to changes in producer price and feed price with regard to all systems. This finding seems reasonable because the higher the variance in the input, the higher the effect of that input on the output. The variance in producer price and feed price was relatively high com-pared with the variance in the other stochastic input variables and implied that CDRM-1 was affected more by external factors than by factors under the farmers' control. Differences in sensitivity to feed prices could be explained by the fact that, in alternative systems and especially in Kemper-Mais Scharrelkip and organic systems, the proportion of fixed costs to variable costs is higher than in conventional systems. Because producer price has a considerable effect on the CDRM-1, a closer investigation of the effect of the level of price premiums follows in a scenario analysis.

Table 5.7 Multivariate stepwise regression values on the cumulative capital debt repayment margin after year 1

	Beta coefficients					
Stochastic variable	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Case 1—New farms						
Producer price	1.10	1.10	1.10	1.11	1.09	1.09
Feed price	−0.55	−0.51	−0.50	−0.50	−0.42	−0.44
Weight at delivery	0.13	0.14	0.15	0.15	0.16	0.16
Feed conversion ratio	−0.11	−0.11	−0.10	−0.10	−0.10	−0.11
Day-old chick price	−0.06	−0.06	−0.05	−0.05	−0.04	−0.04
Mortality	−0.05	−0.04	−0.04	−0.04	−0.05	−0.03
Case 2—Conversion to a new system						
Producer price	1.08	1.10	1.09	1.08	1.08	1.07
Feed price	−0.54	−0.51	−0.50	−0.49	−0.43	−0.45
Weight at delivery	0.12	0.14	0.18	0.18	0.19	0.17
Feed conversion rate	−0.11	−0.11	−0.10	−0.10	−0.10	−0.10
Day-old chick price	−0.06	−0.06	−0.04	−0.05	−0.04	−0.03
Mortality	−0.05	−0.04	−0.05	−0.04	−0.05	−0.04

Scenario Analysis

Scenario 1: No Price Premium

The default situation assumed that farmers received a higher price for more AW-friendly products than for conventional products and that the price premiums were certain, but not the price as a whole. In practice, uncertainty surrounding price premiums is an important factor when choosing a production system. To analyze whether alternative systems are feasible without price premiums, price premiums were eliminated in this scenario.

With regard to case 1 and case 2, all CDF of the alternative systems shifted to the left side on the horizontal axis, implying a zero or close to zero likelihood of positive CDRM at the end of year 5 (Figure 5.2). Hence, compensation for producing under higher AW standards is highly important with regard to the economic feasibility of alternative systems.

Scenario 2: 50% Lower Price Premium, Default Volatility

Price premiums for products produced according to above-legal standards were calculated based on current retail prices. However, this approach allowed only a rough estimation of producer prices given a lack of data on margins through the supply chains. In the broiler industry, farmers are price takers and have little control over prices (Bunte et al., 2003). Hence, AW products may be charged with higher margins than conventional products through the chain, implying that the actual price premium that a farmer receives is lower than the price premium on the end products. These products are also currently produced on a small scale for a niche consumer segment willing to pay a price premium for these products. The share of the middle-market systems of the total animal places is approximately 2% (Ellen et al., 2012). If the demand for AW-friendly products does not increase equally with the supply, lower price premiums will likely be charged at the retail level or not all cut-up parts will be charged a premium. Eventually, these effects will transfer to farmers, resulting in a lower producer price for AW-friendly products. In scenario 2, the aim was to illustrate the possible effects of these phenomena by reducing the default average price premium by 50%.

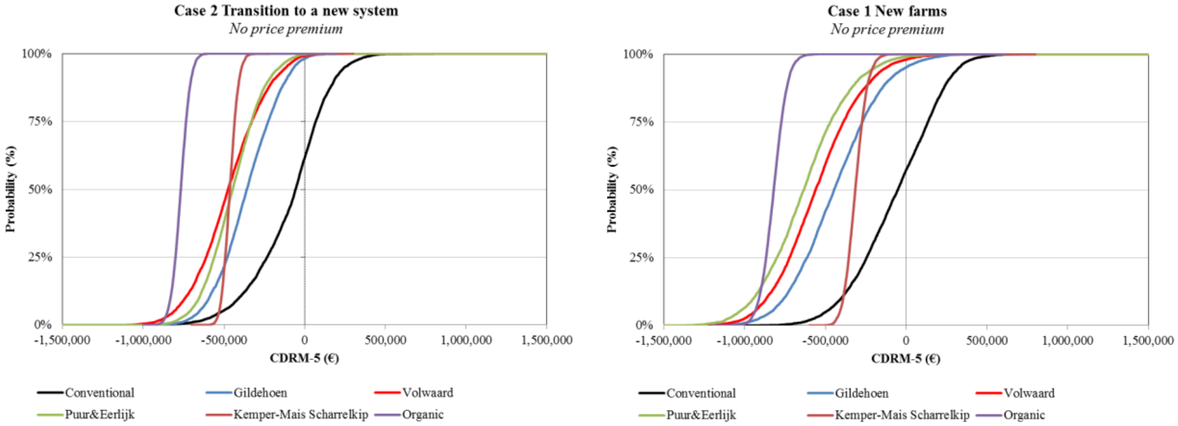

Figure 5.2 Simulated cumulative distribution functions of the cumulative capital debt repayment margin at the end of year 5 (CDRM-5) for case 1 (new farms) and case 2 (transition from conventional to alternative systems) in scenario 1 (no price premium).

The lower tails of the CDF for alternative systems became longer than the upper tail compared with the default situation (Figure 5.3). In case 1, the Kemper-Mais Scharrelkip system had a similar economic feasibility as conventional system but a lower variation in CDRM-5. In case 2, the CDF of the Kemper-Mais Scharrelkip system was closer to the CDF of the organic system and its economic feasibility decreased to zero. In both cases, the other alternative systems had lower economic feasibilities than the conventional system. The CDF for the organic system was to the left of the point representing zero CDRM-5, implying a probability of approximately zero of realizing a positive CDRM-5.

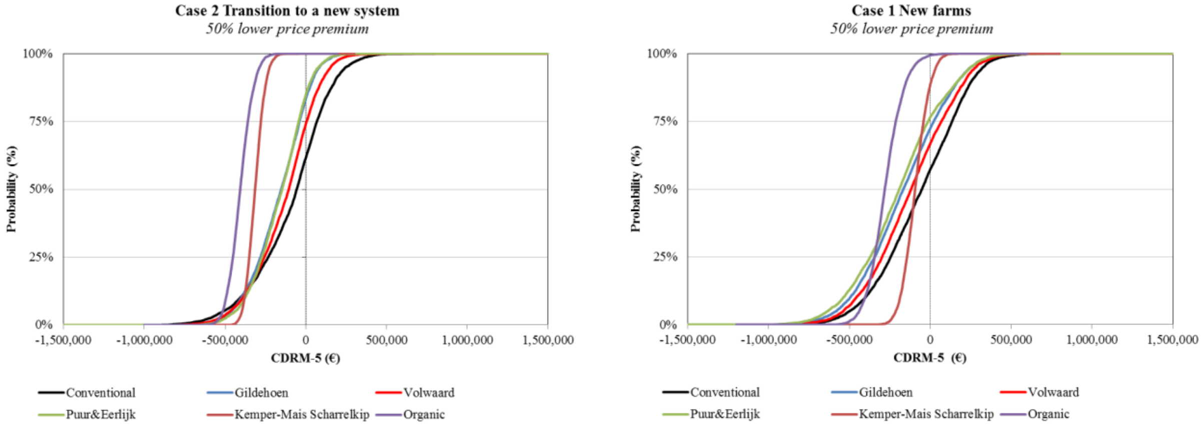

Figure 5.3 Simulated cumulative distribution functions of the cumulative capital debt repayment margin at the end of year 5 (CDRM-5) for case 1 (new farms) and case 2 (transition from conventional to alternative systems) in scenario 2 (50% lower price premium, default volatility).

Scenario 3: 50% Lower Price Premium, High Volatility

Fluctuations in demand for AW-friendly products could lead to more fluctuations in producer prices. Scenario 3 illustrates the situation in which the previously assumed lower average price premium coincided with two times higher volatility than the default (Figure 5.4). Given the high volatility, the range of outcomes of the CDRM-5 increased. Farmers can realize higher margins and higher losses. In this situation, the risk attitude of the farmer becomes more important. The more risk averse the farmer, the higher the return that he was willing to forego for certainty. Because the likelihood of a negative CDRM-5 increases, and the range of the CDRM expands, choosing for an alternative system is less likely in case of a risk-averse farmer than in a situation with a lower volatility in producer prices. Moreover, the level of equity in the business becomes more important because a larger financial buffer suggests that farms can better cope with increased risks.

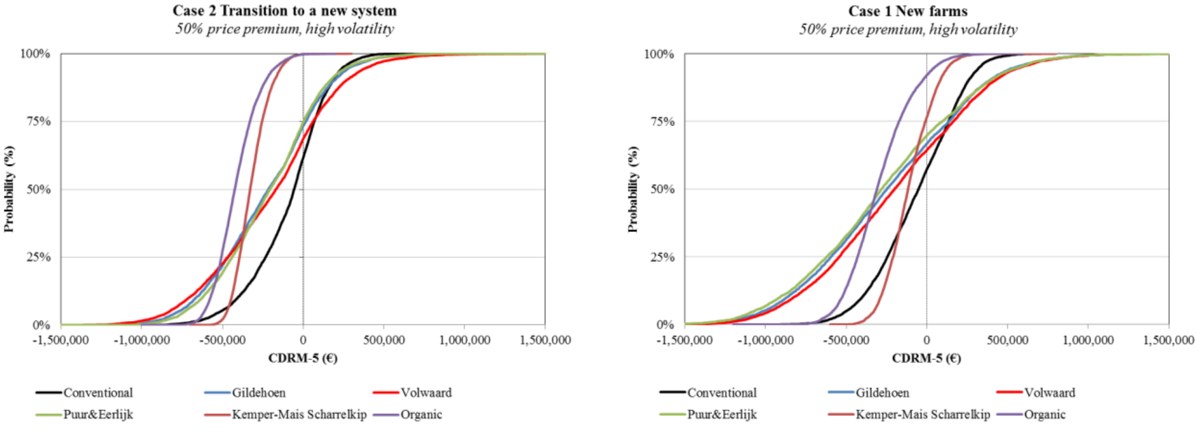

Figure 5.4 Simulated cumulative distribution functions of the cumulative capital debt repayment margin at the end of year 5 (CDRM-5) for case 1 (new farms) and case 2 (transition from conventional to alternative systems) in scenario 3 (50% lower price premium, high volatility).

Discussion

The objective of the study was to analyze the mid-term economic feasibility and risks of different broiler production systems in the Netherlands represented by the cumulative capital debt repayment margin at the end of year 5 (CDRM-5). For this purpose, a stochastic bioeconomic simulation model was developed. The results strongly emphasize the importance of the price premiums associated with AW concepts. Bornett et al. (2003) also explained the importance of maintaining price premiums to ensure long-term profitability when producing pork meat with higher AW standards. In the default situation, when price premiums were assumed certain, new farms with alternative production systems were more economically feasible than conventional farms. In this case, Kemper-Mais Scharrelkip and organic systems had the highest economic feasibility. However, in practice, price premiums can vary and depend particularly on consumer demand (Park and Lohr, 1996). Hence, reducing the price premium for alternative products to zero resulted in a ranking the opposite of that in the default situation. When the default price premium was decreased by 50%, alternative systems performed worse than the conventional system in terms of economic feasibility. This result suggests that if not all of the cut-up parts can be sold at a higher price or a lower price premium can be charged on average, the economic feasibility of alternative systems could be threatened.

In case of transition to an alternative system, differences between systems in terms of economic feasibility tended to decrease. This phenomenon can be explained by the assumption that, in the short-term, no expansion was possible on the farm. Therefore, fewer chickens could be kept in the alternative systems after the transition than on new farms, which resulted in a decrease in farm returns.

Economic feasibility can vary with the stage of the investment cycle. For a conventional farm with outstanding loans, a decrease in the scale of production from limitations on flock size and farm size can reduce the economic feasibility of a Kemper-Mais Scharrelkip or an organic system.

In alternative production systems, farmers may face increased price risk from the uncertainty in price premiums (Lampkin and Padel, 1994). As volatility in producer prices increased, the range of the CDRM-5 expanded. In this situation, the advantage of alternative systems was less obvious and the farmer's risk attitude becomes more important compared with the situation of high price premiums and low producer price volatility. A risk-averse farmer is not only concerned with average performance but also with the likelihood and magnitude of potential losses. Therefore, future studies must take into account the risk attitude. Similarly, Acs et al. (2009) emphasized the importance of accounting for a farmer's risk aversion in strategic planning.

A system was considered economically feasible if the CDRM-5 was greater than or equal to 0. The cumulative capital debt repayment margin was used to compare the economic performance of different production systems. Economic feasibility studies often used different measures for comparison, such as owner's equity and debt-to-equity ratio (Leatham et al., 1986; Lien et al., 2007). However, changes in equity could be caused by factors that this study did not take into account, such as revaluation of assets. The CDRM-5 refers to the amount of cash that remains with the business at the end of year 5 but ignores other factors that might influence the balance sheet. Although the CDRM-5 provided an objective measure of the economic feasibility of production systems, it did not account for the farmers' risk attitudes. Individual farmers might choose higher or lower cut-off points depending on their financial situation and their risk attitude (Hardaker et al., 2004). Although choosing lower or higher cut-off points in most cases does not influence the ranking between production systems, it influences the absolute judgment of economic feasibility.

To carry out the empirical analysis in this study, several assumptions were made. A major overall assumption was that during the five-year period no large changes were expected in terms of external factors, such as changes in legislation, reduction in market, in conventional production. Because data on alternative systems are scarce, assumptions with regard to variations in technical variables and in prices in these alternative systems were made based on variables for conventional systems. Estimates of price premiums were derived from consumer prices without accounting for the possibility that food processing companies and retail entities might operate with different margins for AW-friendly products than for conventional products. Consequently, estimates of price premiums may differ from price premiums in practice. Although possible changes in the market share of the product concepts were not taken into account when calculating price premiums, these changes can influence such premiums (Jehle and Reny, 2011). Therefore, data limitations and assumptions are important to consider when interpreting the results. Nevertheless, better data were not available for this study. Calculations regarding a transition from a conventional to an alternative system did not account for factors that might temporarily hinder production, such as construction work on the farm (for example, building a covered veranda) and, for organic systems, a conversion period to qualify for organic production. These factors might lower returns in the beginning of the transition and can, in turn, slightly change economic feasibility. Producer prices, feed prices, and prices of one-day-old chicks were simulated using geometric random walk models that assumed that prices follow a stochastic trend. Other methods for simulating future prices might yield different outcomes for the different systems.

This study shows that the economic feasibility of improved AW-systems predominantly depends on the prices that farmers receive, prices over which they have little control. Moreover, this study demonstrates the importance of accounting for both the level and the variation of the price premium, particularly during the first five years of production. The economic feasibility of the farm increased with AW requirements, provided that farmers captured a high price level for broiler meat and faced relatively low volatility in producer prices. If this was not the case, differences in farmers' risk attitudes became important and, in turn, the use of potential risk management instruments should be considered. Price risks are largely determined outside the farm. Hence, part of these risks could be managed outside the farm, such as by vertical coordination including contracts (Harwood et al., 1999; Hardaker et al., 2004). The terms of a contract can establish a minimum price level or a minimum price premium for AW products that fulfill certain quality requirements. In this way, part of a farmer's price risks are eliminated, but farmers are still be left with considerable freedom in management decisions. Stronger forms of vertical coordination include production contracts and vertical integration, in which the types of resources (for example, feed and antibiotics) that farmers can use are usually regulated and the integrator or buyer makes some of the production decisions. All such instruments focus on reducing price volatility and, in turn, decrease downside risk at the farm level. However, these instruments also limit entrepreneurial freedom to a smaller or a larger extent. The AW concepts currently present in the Netherlands already use particular forms of vertical coordination. For example, one of the concepts guarantees a feed profit for farmers; in other words, if the feed price increases producer price increases accordingly, and vice versa, sets requirements on flock size among others, and integrates the process from transportation through slaughter to selling products to the retail channel (KemperKip, 2013). Such risk management instruments could increase the willingness of farmers to convert to AW improving production systems. However, in addition to farmers possibly expressing of some degree of risk aversion, Dutch farmers consider themselves entrepreneurs and want to keep their freedom of choice (van Horne, 2007). The extent to which farmers perceive these instruments as a motivation to join a concept and from what point these instruments become a limiting factor for farmers could differ at an individual level and needs to be further studied.

The study focused on Dutch broiler production. However, the main findings also apply to other countries in which AW is of public concern (e.g., other EU countries, United States, and Australia; Robins and Phillips, 2011) and in which farmers face a similar decision problem (i.e., a choice of switching to an alternative production system or not; as explained in section 2, France and the United Kingdom have alternative production systems similar to the Dutch systems). In Western European countries, particularly Germany, Great Britain, Belgium, and France, several key issues are quite similar to the Dutch situation. First, the specialized broiler production occurs in a pyramidal chain (Oosterkamp et al., 2011). Second, a similar demand structure of the market ranges from conventional to high-level organic with an expanding middle-market segment in between (Roex and Miele, 2005). Third, a similar approach is followed to improve AW, primarily through market-based incentives that foster the division of roles and responsibilities across the supply chain (for example, Great Britain; DEFRA, 2004).

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Appendix 5

Scheme for Calculating Income Tax

1. *Calculation of taxable income*

Profit from farm (= Net farm income)

- Investment deduction

Investment amount	Investment deduction
≤ €2.300	€0
€2,301 - €55,248	28% of the investment amount
€55,249 – €102,311	€15,470
€102, 312 - €306,931	€15,470 decreased by 7.56% of the part of investment that exceeds €102,311
≥ €306,932	€0

- Loss transfer
- Self-employed person's allowance maximum €7,288

Taxable income

2. *Calculation of income tax*

Income tax calculated based on the tax brackets

Tax bracket	Taxable income (€)	Income tax (incl. social security contributions) (%)
1st bracket	≤ €18,945	33,1%
2nd bracket	€18,945 - €33,863	41,95%
3rd bracket	€33,864 – €56,491	42%
4th bracket	≥ €56,492	52%

- General tax credit €2,033
- Labor tax credit maximum €1,611

Total income tax

Figure 5A.1 Calculation of tax income

References

Acs, S., Berentsen, P., Huirne, R., van Asseldonk, M. (2009). Effect of yield and price risk on conversion from conventional to organic farming. Australian Journal of Agricultural Resource Economics, 53:393–411. http://dx.doi.org/10.1111/j.1467-8489.2009.00458.x.

Barry, P.J., Ellinger, P.N. (2012). Financial Management in Agriculture. 7th ed. NJ, USA: Prentice Hall Upper Saddle River.

Bewley, J.M., Boehlje, M.D., Gray, A.W., Hogeveen, H., Kenyon, S.J., Eicher, S.D., Schutz, M.M. (2010). Stochastic simulation using @Risk for dairy business investment decisions. Agricultural Finance Review, 70:97–125.

Bokkers, E.A.M., de Boer, I.J.M. (2009). Economic, ecological, and social performance of conventional and organic broiler production in the Netherlands. British Poultry Science, 50:546–557. DOI: http://dx.doi.org/10.1080/00071660903140999.

Bornett, H.L.I., Guy, J.H., Cain, P.J., (2003). Impact of animal welfare on costs and viability of pig production in the UK. Journal of Agricultural and Environmental Ethics, 16:163–186. DOI: http://dx.doi.org/10.1023/A:1022994131594.

Bunte, F.H.J., Kuiper, W.E., van Galen, M.A., Goddijn, S. (2003). Macht en prijsvorming in agrofoodketens, Rapport 5.03.01. LEI, Wageningen UR, The Hague, the Netherlands.

Castellini, C., Boggia A., Cortina, C., Dal Bosco, A., Paolotti, L., Novelli, E., Mugnai, C. (2012). A multicriteria approach for measuring the sustainability of different poultry production systems. Journal of Cleaner Production, 37:192–201. DOI: http://dx.doi.org/10.1016/j. jclepro.2012.07.006.

CBS. (2012). Statistics Netherlands. Available at http://statline.cbs.nl/StatWeb/dome/default.aspx. Accessed 13-12-2012.

De Jonge, J., van Trijp H.C.M. (2013). Meeting heterogeneity in consumer demand for animal welfare: A reflection on existing knowledge and implications for the meat sector. Journal of Agricultural and Environmental Ethics, 26:629–661.

DEFRA. (2004). Animal Health and Welfare Strategy. DEFRA, London, UK.

Den Ouden, M. (1996). Economic modelling of pork production-marketing chains. PhD. Wageningen Agricultural University, Wageningen, the Netherlands.

Ellen, H., Leenstra, F., van Emous, R., Groenestein, K., van Harn, J., van Horne, P., de Jong, I., Kense, M., Mevius, D., Wagenaar, J. A. (2012). Vleeskuikenproductiesystemen in Nederland, Rapport 619. Livestock Research, Wageningen University and Research Centre, Lelystad, the Netherlands.

Fabozzi, F.J., Markowitz, H.M. (2011). The theory and practice of investment management: Asset Allocation, Valuation, Portfolio Construction, and Strategies. John Wiley & Sons Inc., Hoboken, NJ.

Gebrezgabher, S.A., Meuwissen, M.P.M., Oude Lansink, A.G.J.M. (2012). Energy-neutral dairy chain in the Netherlands: An economic feasibility analysis. Biomass Bioenergy, 36:60–68. DOI: http://dx.doi.org/10.1016/j.biombioe.2011.10.006.

Hansen, J.W., Jones, J.W. (1996). A systems framework for characterizing farm sustainability. Agricultural Systems, 51:185–201. DOI: http://dx.doi.org/10.1016/0308-521x(95)00036-5.

Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., Lien, G.. (2004). Coping with Risk in Agriculture. 2nd ed. CABI, Wallingford, UK.

Harwood, J., Heifner, R., Coble, K., Perry, J., Somwaru, A. (1999). Managing risk in farming: Concepts, Research, and Analysis, Agricultural Economic Report No. 774. USDA, Economic Research Service, Washington, DC.

Hyde, J., Engel, P. (2002). Investing in a robotic milking system: A Monte Carlo simulation analysis. Journal of Dairy Science, 85:2207–2214. DOI: http://dx.doi.org/10.3168/jds.S0022-0302(02)74300-2.

Jehle, G.A., and Reny, P.J. (2011). Advanced Microeconomic Theory. 3rd ed. Prentice Hall, New Jersey.

Kay, R.D., Edwards, W.M., Duffy, P.A. (2012). Farm Management. McGraw-Hill Higher Education, New York, NY.

KemperKip. (2013). Home page. Available at http://www. kemperkip.com/kemper/index.php. Accessed 19-03-2013.

KWIN-V. (2011). Kwantitatieve Informatie Veehouderij 2011–2012. Wageningen UR Livestock Research, Lelystad, the Netherlands.

Lampkin, N.H., Padel, S. (1994). The economics of organic farming: An international perspective. CAB International, Wallingford, UK.

Leatham, D.J., Pery, G.M., Edward Rister, M., Rischardson, J.W. (1986). Farm survival and performance under alternative financial conditions and credit policies. Agribusiness, 2:321–337.

LEI and CBS. (2011). Land- en tuinbouwcijfers 2011, LEI-rapport 2011–029. LEI, Wageningen UR and Central Bureau of Statistics, The Hague, the Netherlands.

LEI. (2012). Bedrijfsinformatienet. Agricultural Economics Research Institute. Available at http://www3.lei.wur.nl/BIN_ ASp/Frm_Start_Binternet.aspx?Database=Prijzen. Accessed 13-03-2013.

Lien, G. (2003). Assisting whole-farm decision-making through stochastic budgeting. Agricultural Systems, 76:399–413.

Lien, G., Hardaker, J.B., Flaten, O. (2007). Risk and economic sustainability of crop farming systems. Agricultural Systems, 94:541–552. DOI: http://dx.doi.org/10.1016/j.agsy.2007.01.006.

Meuwissen, M.P.M., Hardaker, J.B., Huirne, R.B.M., Dijkhuizen, A.A. (2001). Sharing risks in agriculture;

principles and empirical results. Netherlands Journal of Agricultural Science, 49:343–356.

Nelson, C.R., Plosser, C.I. (1982). Trends and random-walks in macroeconomic time-series - Some evidence and implications. Journal of Monetary Econonomics, 10:139–162. DOI: http://dx.doi.org/10.1016/0304-3932(82)90012-5.

Oosterkamp, E.B., Bremmer, B., Hoste, R., de Greef, K.H. (2011). Verkenning van dierlijke tussensegment in onze buurlanden: Duurzam varkensvlees, pluimveevlees en eieren, LEI-rapport 2011–028. LEI, Wageningen UR, The Hague, the Netherlands.

Park, T.A., Lohr, L. (1996). Supply and demand factors for organic produce. American Journal of Agricultural Economics, 78:647–655. DOI: http://dx.doi. org/10.2307/1243282.

Pennings, J.M.E., Smidts, A. (2000). Assessing the construct validity of risk attitude. Management Science, 46:1337–1348.

PPE. (2004). Verordening aanduiding bijzondere slachtpluimveehouderijsystemen (PPE) 2004. Available at http://maxius.nl/verordening-aanduiding-bijzondere-slachtpluimvee-houderijsystemen-ppe-2004. Accessed 11-03-2013.

PVE. (2012). Livestock, Meat and Eggs in the Netherlands, Annual Survey 2011. Dutch Product Boards for Livestock Meat and Eggs, Zoetermeer, the Netherlands.

Robins, A., Phillips, C.J.C. (2011). International approaches to the welfare of meat chickens. World’s Poultry Science Journal, 67:351–369. DOI: http://dx.doi.org/10.1017/S0043933911000341.

Roex, J., Miele, M. (2005). Farm Animal Welfare Concerns, Consumers, Retailers and Producers. Cardiff University, Cardiff, UK.

SCAHAW. (2000). The welfare of chickens kept for meat production. Report SANCO.B.3/AH/R15/2000. Scientific Committee on Animal Health and Animal Welfare, European Commission, Brussels, Belgium.

Seibert, L., Norwood, F.B. (2011). Production costs and animal welfare for four stylized hog production systems. Journal of Applied Animal Welfare Science, 14:1–17. DOI: http://dx.doi.org/10.1080/10888705.2011.5 27596.

SKAL-Tarievenblad. (2012). Stichting SKAL. Available at http://www.skal.nl/LinkClick.aspx?fileticket=bzNvKVTMgWM%3D&tabid=99&language=nl-NL. Accessed 13-12-2012.

Van der Veen, H.B., van der Meulen, H.A.B., van Bommel K.H.M., Doorneweert, B. (2007). Exploring agricultural taxation in Europe, Report 2.07.06. LEI, Wageningen UR, The Hague, the Netherlands.

Van Horne, P. (2007). Ketenorganisatie van de Nederlandse vleeskuikensector in internationaal perspectief. Verantwoorde Veehouderij, Wageningen University, Wageningen, the Netherlands.

Van Horne, P.L.M., Achterbosch, T.J. (2008). Animal welfare in poultry production systems: Impact of EU standards on world trade. World's Poultry Science Journal, 64:40–52.

Van Horne, P.L.M., van Harn, J., van Middelkoop J.H., Tacken, G.M.L. (2003). Perspectieven voor een alternatieve kuikenvleesketen, Marktkansen voor een langzaam groeiend vleeskuiken. Rapport 2.03.20. LEI, Wageningen UR, The Hague, the Netherlands.

Van Huik, M.M., Bock, B.B. (2007). Attitudes of Dutch pig farmers towards animal welfare. British Food Journal, 109:879–890. DOI: http://dx.doi.org/10.1108/00070700710835697.

Vermeij, I. (2004). Primaire productiekosten biologisch kuikenvlees. Intern Rapport 505. Wageningen UR, Animal Sciences Group, Lelystad, the Netherlands.

Vermeij, I., van Horne P.L.M. (2008). Kostprijs biologische vleeskuikens, Rapport 170. Animal Sciences Group Wageningen University, Lelystad, the Netherlands.

Verspecht, A., Vanhonacker, F., Verbeke, W., Zoons, J., van Huylenbroeck G. (2011). Economic impact of decreasing stocking densities in broiler production in Belgium. Poultry Science, 90:1844-1851. DOI: http://dx.doi.org/10.3382/ps.2010-01277.

Chapter 6

Effects of different broiler production systems on health care costs in the Netherlands

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Abstract

This study analyzed the effects of different broiler production systems on health care costs in the Netherlands. In addition to the conventional production system, the analysis also included 5 alternative animal welfare systems representative of the Netherlands. The study was limited to the most prevalent and economically relevant endemic diseases in the broiler farms. Health care costs consisted of losses and expenditures. The study investigated whether higher animal welfare standards increased health care costs, in both absolute and relative terms, and also examined which cost components (losses or expenditures) were affected and, if so, to what extent. The results show that health care costs represent only a small proportion of total production costs in each production system. Losses account for the major part of health care costs, which makes it difficult to detect the actual effect of diseases on total health care costs. We conclude that, although differences in health care costs exist across production systems, health care costs only make a minor contribution to the total production costs relative to other costs, such as feed costs and purchase of one-day-old chicks.

Keywords: Animal welfare, Animal health, Economic analysis, Broiler production

Introduction

In recent years, increasing requirements regarding animal welfare (AW) in broiler production have led to the development of production systems that comply with above-legal AW standards (Blokhuis et al., 2003; Fraser, 2006). Although these standards contribute to improved AW, they also increase production costs (Verspecht et al., 2011). Furthermore, productivity and profitability might be negatively affected if higher production costs do not increase economic returns (McInerney, 2004).

Although livestock diseases occur in broiler farms regardless of which production system is used, the likelihood and the effect of livestock diseases can differ depending on the production system. However, the possible effect of AW-friendly production systems on animal health is not clear. Lister and van Nijhuis (2012) suggested that the prevalence of coccidiosis or other parasitic infections was higher in systems in which chickens had access to an outdoor area, such as free-range or organic systems. Also, broiler chickens in organic systems showed an increased prevalence of *Campylobacter* compared with chickens in conventional systems. Cui et al. (2005) found that organic chickens were more frequently contaminated with *Campylobacter* and *Salmonella*. In contrast, van Overbeke et al. (2006) found no significant difference in the prevalence of *Salmonella* between broiler chickens kept in organic and those kept in conventional systems.

With respect to the possible effect of AW-friendly production systems on animal health, a distinction must be made between prevalence (that is, the likelihood of introduction) and effect. Increased disease prevalence and a greater effect of a disease both result in increased health care costs. Health care costs include all economic effects of a disease and are the sum of 2 components: losses and expenditures (McInerney, 1996). Losses can be caused, for example, by mortality, morbidity, reduced production efficiency, and lower meat yield and quality, which results in reduced returns. Extra expenditures are mainly the costs of veterinary prophylactic and therapeutic treatments to prevent or treat a disease (McInerney et al., 1992; Bennett, 2003; Houe, 2003; Bennett and Ijpelaar, 2005).

The aim of this study was to analyze the effects of different production systems on health care costs. First, we investigated whether higher AW standards increased health care costs in both absolute and relative terms. Second, we examined which cost components (losses or expenditures) were affected and to what extent. This study was restricted to the most important endemic diseases. Epidemic diseases, such as avian influenza, were not included because they occur only rarely and the differentiation between conventional, free-range, and organic was less relevant.

Materials and Methods

Broiler Production in the Netherlands

Dutch legislation defining standards of broiler production is based on the European Union guidelines (EC, 2007a,b, 2008). In the Netherlands, several so-called AW concepts, such as private labels, have been developed in recent years setting higher requirements for production in terms of AW compared with the minimum standards of conventional broiler production. Table 6.1 describes the main requirements for conventional production and 5 alternative AW concepts (also referred to as AW systems later in the text) representative for the Netherlands. A conventional system is defined according to European Union standards. The Better Life hallmark initiated by the Dutch Society for the Protection of Animals (Dierenbescherming) enables a transparent differentiation among animal products in terms of AW. Products that can be produced under different concepts are labeled with a distinctive Better Life logo if they comply with the requirements of this hallmark. Three categories are distinguished within the Better Life hallmark depending on the level of AW: Better Life 1*, Better Life 2*, and Better Life 3*. The number of stars increases as the assumed level of welfare increases. Puur en Eerlijk products fit under the Better Life 1* concept. This concept has the same requirements as in the Volwaard concept, except that a lower stocking density is required (25 kg per m ^{2}). The requirements of Better Life 3* concept are the same as the production standards of SKAL (the independent organization that audits organic systems in the Netherlands). The organic standards of SKAL are different from the European Union standards for organic production, but the European Union standards should eventually be implemented in all European Union countries, which means that the European Union standards for organic production are included in the study as well.

Endemic Diseases Included in the Study

The study was limited to the most important endemic diseases because it was not possible to include all poultry diseases that can occur on a broiler farm. The selection of diseases was mainly based on Bergevoet et al. (2010), who identified the most important diseases and disorders in a broiler farm in the Netherlands by scoring them on several aspects, such as

Table 6.1 Requirements and criteria of selected animal welfare concepts (Ellen et al., 2012)

	Production systems					
Criteria	Conventional	Volwaard	Better Life 1*/ Puur en Eerlijk	Better Life 2*	Better Life 3*/ Skal	Organic
Breed	Fast-growing	Slower-growing	Slower-growing	Slower-growing	Slow-growing	Slow-growing
Length of growth period (day)	40	56	56	56	81	70
Enrichment	Litter	Litter, grains, and straw	Litter, grains, and straw	Litter, grains, and straw	Litter	Litter
Stocking density (chicken/m^2)	No restriction	No restriction	12	13	7	10
Stocking density (kg/m^2)	42	31	25	27.5	No restriction	No restriction
Outdoor access	No	Covered veranda	Covered veranda	Yes (1 m^2/chicken)	Yes (1.5 m^2/chicken)	Yes (4 m^2/chicken)
Lighting regimen	Unnatural (minimum 4 h dark period)	Natural (minimum 6 h dark period)	Natural (minimum 6 h dark period)	Natural (minimum 8 h dark period)	Natural (minimum 8 h dark period)	Natural (minimum 8 h dark period)
Flock size	No restriction	No restriction	No restriction	No restriction	No restriction	Maximum 4,800 chickens per barn
Use of antibiotics	No restriction	No restriction	No restriction	No restriction	Coccidiostat and preventive drugs are prohibited	Coccidiostat and preventive drugs are prohibited

epidemiology and business economics. In this way, infectious bronchitis (IB), coccidiosis, *Escherichia coli*, and necrotic enteritis (NE) were included in this study, along with infectious bursal disease (IBD), sudden death syndrome (SDS), ascites, and leg problems (European Commission, 2000; De Jong et al., 2012).*nterococcus*, which had a relatively high score in terms of epidemiological and business economics aspects, had to be excluded because little is known about its spread and pathogens (Bergevoet et al., 2010).Diseases for which vaccinations are obligatory in the Netherlands, such as Newcastle disease, were excluded from the study (GD, 2012). The selected diseases were considered to be the most prevalent diseases in the broiler farms; they were economically relevant and could be distinguished between systems (Ruff, 1999; European Commission, 2000; Bennett and Ijpelaar, 2005; Rushton, 2009; Bergevoet et al., 2010; De Jong et al., 2012). Because the prevalence and severity of diseases of a particular organ system can differ depending on housing conditions, the 8 selected diseases were categorized into 5 groups according to organ system: diseases concerning the respiratory system (IB), the organs of immune system (IBD), the gastrointestinal tract (coccidiosis, *E. coli*, and NE), the locomotion system (leg problems), and the heart and vascular system (ascites and SDS; Table 6.2). The final selection was discussed with an expert from the Dutch Animal Health Service who specializes in poultry diseases (J. J. de Wit, Dutch Animal Health Service, Deventer, the Netherlands, personal communication).

Definition of Health Care Costs

McInerney et al. (1992) defined health care costs ($\boldsymbol{C}$) as the sum of losses ($\boldsymbol{L}$) and expenditures ($\boldsymbol{E}$). A loss implies a foregone benefit, such as lower revenue or lower productivity as a consequence of slower growth (McInerney et al., 1992; McInerney, 1996). Expenditures mainly originate from disease prevention and treatments (McInerney et al., 1992). Evidently, a trade-off exists between L and E: higher treatment and prevention expenditures result in lower losses, and vice versa; the optimal level of L and E is determined by the prices of inputs and outputs (McInerney, 1996). It is possible that a lower output caused by a disease coincides with a lower input such as feed consumption. In this case, the loss can be calculated in such a way that the input saved is deducted from the loss incurred (McInerney et al., 1992).

Calculation Approach

To enable calculation of absolute and relative production costs, a baseline situation must first be defined: no endemic disease present on the farm. System requirements, such as breed, enrichment, stocking density, and input variables (mortality, feed conversion, and so on) differ

Table 6.2 Diseases and health problems on the broiler farm

			Effect on business economics[1]				
Disease	Cause	Effect on efficiency/production	Mortality	Growth	Feed	Prevention	Treatment
Respiratory							
Infectious bronchitis[2]	Coronavirus[2]	Mortality due to suffocation[2]	++[3]	-[3]	-[3]	Vaccination, hygiene[2]	Good housing conditions and extra heating[4,5]
						All-in, all-out system	
Immune organs							
Infectious bursal disease[6]	Virus[6]	Mortality[7,8,9]	+[7,8]	-[9]	-[9]	Vaccination[10,11,12]	No[5,12]
		Reduced feed and water intake					
Gastrointestinal							
Coccidiosis[13]	*Eimeria acervulina*[14,15]	Weight loss[16]	+[17]	-[18,19]	++[18,19]	Vaccination[20,21,22]	Chemotherapy
	Eimeria maxima[14,15]	Reduced growth rate				Anticoccidial drugs in feed	Remove wet litter
	Eimeria tenella[14,15]	Mortality				Hygiene (disinfectant)	
		Increased feed conversion					
Escherichia coli	*E. coli*[23]	Mortality	+[24]	-[25]	-[26]	Hygiene[23,27]	Antibiotics[26]
(including peritonitis)[23]						Good ventilation	
Necrotic enteritis[28]	*Clostridium perfringens* type C	Mortality[19,29]	+	-[12]	0	Adjusted feed composition	Antibiotics[5]
						Prevention of coccidiosis	
						General hygiene[5]	
						10% solution formalin	
						Pre- and probiotics	
Locomotion							
Leg problems[30,31,32]	Genetic predisposition[33]	Skin irritation and blisters, footpad dermatitis and hock burn	0	-[34]	0	Various management factors such as limiting feed, meal feeding, and lighting schedule[31,35,36,37]	No
	Metabolic disorders	Reduced feed intake					
	Feed composition						
	Lack of movement						

Continued

Table 6.2 (Continued) Diseases and health problems on the broiler farm

			Effect on business economics[1]				
Disease	Cause	Effect on efficiency/production	Mortality	Growth	Feed	Prevention	Treatment
Heart and vascular							
Ascites[38]	Selection	Condemnation[38] Mortality	++[39]	0	0	Slower growth rate[30] Feed with a lower energy content	No
Sudden death syndrome[40]	Selection	Mortality	++[41]	0	0	Slower growth rate[42,43,44] Feed with a lower energy content	No

[1] – = much lower; - = lower; 0 = equal; + = higher; ++ = much higher. Effect is compared with the healthy situation.

[2] Cavanagh, 2003

[3] Yohannes et al., 2012

[4] Lopez et al., 2006

[5] KWIN-V, 2011

[6] Lasher and Shane, 1994

[7] Sanchez et al., 2005

[8] Cavanagh, 1992

[9] McIlroy et al., 1989

[10] BCFI, 2012

[11] McIlroy et al., 1992

[12] Saif et al., 2003

[13] Ruff, 1999

[14] Graat et al., 1996

[15] Haug et al., 2008

[16] Voeten, 2000

Continued

Table 6.2 (Continued) Diseases and health problems on the broiler farm

[17] Williams, 1999

[18] Williams, 1998

[19] Voeten et al., 1988

[20] Wheelhouse et al., 1985

[21] Vermeulen et al., 2001

[22] Steenhuisen and Vossen, 2001

[23] Kabir, 2010

[24] Rahman et al., 2004

[25] Tian and Baracos, 1989

[26] Fernandez et al., 1998

[27] Dziva and Stevens, 2008

[28] McDevitt et al., 2006

[29] Brigden and Riddell, 1975

[30] Julian, 2005

[31] Estévez, 2007

[32] De Jong et al., 2012

[33] Manning et al., 2007

[34] Weeks et al., 2000

[35] Su et al., 1999

[36] Fanatico et al., 2005

[37] Knowles et al., 2008

[38] Olkowski et al., 1996

[39] De Smit et al., 2005

Continued

Table 6.2 (Continued). Diseases and health problems on the broiler farm

[40] Newberry et al., 1987

[41] Julian, 1998

[42] Havenstein et al., 1994

[43] van Horne et al., 2003

[44] Bricket et al., 2007

by production systems. These differences have an effect on production costs, which means that baseline situations had to be calculated for each production system. Health care costs are determined by the prevalence and effect of a disease, both of which differ by production systems. The change in production costs due to a disease regarding a particular production system, that is, absolute effect, was calculated as the difference between the production costs in the baseline situation (healthy) and the production costs in the situation with a particular endemic disease. Calculation of absolute effect only partly enables a comparison between production systems. For a more detailed comparison, 2 relative measures were calculated: the relative effect on production costs and the proportion of the health care costs in total production costs. The relative effect on production costs was determined as the ratio of the increase in production costs due to a disease to production costs in the healthy baseline situation. To obtain the proportion of health care costs in total production costs, the absolute effect was divided by the total production costs in the situation with a particular disease.

Model

The model described by Gocsik et al. (2013) was adapted to calculate the economic effect of a disease; that is, change in production costs under different production systems. The model was adjusted with some technical, economic, and veterinary inputs, such as disease prevalence and effect on production parameters. Stochastic inputs were replaced by deterministic inputs. Production and health care costs were calculated for each delivered broiler in an Excel (Microsoft Corp., Redmond, WA) model using the partial budgeting approach (Dijkhuizen and Morris, 1997).

The model included 4 factors through which disease occurrence might influence productivity and production costs. The negative effects on productivity (losses) as a consequence of a disease occurrence are increased mortality, decreased daily weight gain, increased feed conversion, and an increased condemnation rate at slaughter.

Increase in mortality due to a disease affects the cost of mortality, which was calculated using equation [1]:

$$Cost\ of\ mortality = \left(price\ dayold\ chick + \left(\frac{(producer\ price\ x\ weight\ at\ delivery) - price\ dayold\ chick}{2}\right) - cost\ of\ delivery\right)\ x\ (mortality) \qquad \mathbf{6.1}$$

The chickens were assumed to die in the middle of the production period. The fixed costs per delivered broiler chicken may change due to an increased mortality because fewer chickens are delivered.

Decrease in daily weight gain affects fixed costs. The chickens were assumed to be kept until they reached the required weight to be delivered. Due to a lower daily weight gain, more days are required to reach the delivery weight. A longer production period results in fewer production rounds per year and, eventually, in a decrease in the number of delivered broiler chickens. Thereby, the fixed costs such as cost of housing and labor per delivered broiler chicken increase.

Increase in feed conversion ratio affects feed costs. Extra feed costs were calculated using equation [2]:

$$Extra\ feed\ costs = \left(\frac{weight\ at\ delivery}{1000}\right) x\ feed\ conversion\ x\ feed\ price \qquad \textbf{6.2}$$

In the above equation, only the feed conversion rate changed as a consequence of the disease, whereas other variables held constant.

Condemnation rate at slaughter affects revenues. If a broiler chicken at the slaughterhouse is rejected, the production costs are already incurred, but little or no revenue is made. The cost of condemnation rate was calculated using equation [3]:

$$Cost\ of\ condemnation\ at\ slaughter =$$

$$\big(price\ dayold\ chick + (producer\ price\ x\ weight\ at\ delivery)\big) x\ condemnation\ rate \qquad \textbf{6.3}$$

The fixed costs per delivered broiler chickens also changed because fewer chickens were delivered. The chickens were assumed to have been rejected as a whole because little or no literature on partial or complete condemnation was available for the diseases concerned (Ellen et al., 2012). Note that birds with leg problems, however, are usually not rejected as a whole. In the Netherlands, the main reasons for rejections are indicated, but rejections are not represented with number per reason of rejection. Carcasses can be rejected for disease and non-disease-related reasons. Due to lack of information on the reasons for rejection, all carcasses are assumed to be rejected for disease-related reasons.

Model Inputs

Technical Inputs

The criteria and requirements of various production systems presented in Table 6.1 were converted into model inputs (Table 6.3). Technical inputs were gathered from the literature and represented the average performance of the farms (van Horne et al., 2003; Vermeij and van

Horne, 2008; van Horne, 2009; KWIN-V, 2011; Ellen et al., 2012). All farms were assumed to be managed by one full-time labor equivalent (FTE).

Table 6.3 Technical inputs by production systems

	Production systems					
Input variables	Conventional	Volwaard	Better Life 1*/ Puur en Eerlijk	Better Life 2*	Better Life 3*/ Skal	Organic
Full-time labor equivalent	1	1	1	1	1	1
No. of birds	90,000 [1]	66,946 [2]	58,580 [2]	52,073 [2]	25,000 [3]	25,000 [3]
Vacancy [3] (d)	10	10	10	10	10	10
Flocks per year [4] (no.)	7.16	5.5	5.5	5.5	4	4.6
Average daily weight gain [5] (g)	54	41	41	38	35	37
Weight at delivery (g)	2,250 [6]	2,300 [2]	2,300 [2]	2,100 [2]	2,800 [3]	2,600 [3]
Feed conversion rate (g/g)	1.75 [2]	2.09 [2]	2.09 [2]	2.15 [2]	2.75 [3]	2.63 [3]
Mortality (%)	4.0 [6]	1.5 [6]	1.5 [6]	1.5 [6]	3.0 [3]	2.8 [3]

[1] KWIN-V, 2011.

[2] Ellen et al. (2012).

[3] Vermeij and Van Horne (2008).

[4] 365/(vacancy + length production period).

[5] Weight at delivery/length production period.

[6] van Horne et al. (2003).

Veterinary inputs

In line with the calculation approach described above, production costs were calculated by production system when diseases were absent and present on the farm. Health care costs were determined in conventional and AW systems by the prevalence and effect of the particular disease. A thorough literature review was conducted to collect data on the prevalence and effect of various diseases. In cases where data on AW systems were not available, an expert was consulted to estimate some of the inputs (J.J. de Wit, Dutch Animal Health Service, Deventer, the Netherlands, personal communication). Estimations regarding the prevalence and effect of various diseases in AW systems were made by relating these inputs to those referring to the conventional system. Although health risk could greatly vary across individual farms, these differences were not taken into account (J.J. de Wit, Dutch Animal Health Service, Deventer, the Netherlands, personal communication). Table 6.4 presents the prevalence of selected diseases under different production systems.

The requirements of AW concepts may decrease or increase the disease prevalence, but may also affect the effect of the disease on the production parameters. The important production parameters that the disease may affect are mortality, daily weight gain, feed conversion ratio, and condemnation rate at slaughter. Table 6.5 presents the effect of various diseases.

Economic Inputs

Table 6.6 presents the economic inputs used to calculate the production costs for each production system. Input data were derived from literature (Steenhuisen and Vossen, 2001; Puister, 2009; PVE, 2011; KWIN-V, 2011; Gocsik et al., 2013).

Table 6.4 Prevalence of various diseases and disorders by production systems (%)

	Production systems					
Diseases	Conventional	Volwaard	Better Life 1* / Puur en Eerlijk	Better Life 2*	Better Life 3* /Skal	Organic
IB [1]	0	0	0	0	0	0
IBD	0 [2]	0 [3]	0 [3]	0 [3]	0 [3]	0 [3]
Coccidiosis	34.4 [4]	61.6 [5]	62.1 [6]	62.1 [6]	65.5 [7]	65.5 [7]
E.coli	100 [8]	100 [9]	100 [9]	100 [9]	100 [10]	100 [10]
NE	12.3 [11]	15.7 [12]	15.7 [12]	15.7 [12]	15.7 [12]	15.7 [12]
Leg problems (GS > 3) [22]	11.35 [13]	0.6 [14]	0.6 [14]	0.6 [14]	0 [15]	0 [15]
Ascites	3.3 [16]	1.7 [17]	1.7 [17]	1.7 [17]	0 [18]	0 [18]
SDS	0.8 [19]	0.4 [20]	0.4 [20]	0.4 [20]	0 [21]	0 [21]

[1] No change in disease prevalence across systems due to vaccination of one-day-old chicks and a lack of research with regard to risk factors (Cook et al., 1999; Lopez et al., 2006). Re-vaccination is assumed to provide a protection level of 100% against the infectious bronchitis (IB) virus. In case of no vaccination, morbidity in the flock is 90% (Cook et al., 1999; Cavanagh, 2003).

[2] Although Homer et al. (1992) found a prevalence rate of 13.3%, the present study assumed that birds have been vaccinated against infectious bursal disease (IBD), indicating that IBD does not occur on the farm. Cavanagh (2003) suggested that vaccination against IBD provides 100% protection. According to Voeten (2000), vaccination is necessary to prevent loss due to IBD. In this study, IBD vaccination is assumed to provide 100% protection.

[3] No literature has been found indicating an increase in prevalence due to wild birds (Gilchrist, 2005). In the present study, IBD vaccination is assumed to provide 100% protection.

[4] Infection level >50,000 oocysts (Haug et al., 2008).

Continued

Table 6.4 (Continued) Prevalence of various diseases and disorders by production systems (%)

[5] Free-range area and lower stocking density: 59.1% (Williams et al., 1996). Increase due to a longer daylight period (6 h): a small increase in coccidiosis is expected due to a longer daylight period, which results in more activity in this period and, in turn, increases the likelihood of picking up oocysts from the environment (Henken et al., 1992). Therefore, the estimated increase in prevalence is 2.5%.

[6] Free-range area and lower stocking density: 59.1% (Williams et al., 1996). Increase due to a longer daylight period (8 h): a small increase in coccidiosis is expected due to a longer daylight period, which results in more activity in this period and, in turn, increases the likelihood of picking up oocysts from the environment (Henken et al., 1992). Therefore, the estimated increase in prevalence is 3.0%.

[7] Free-range area, use of prevention drugs prohibited, and lower stocking density: 62.5% (Williams et al., 1996). Increase due to a longer daylight period (8 h): a small increase in coccidiosis is expected due to a longer daylight period, which results in more activity in this period and, in turn, increases the likelihood of picking up oocysts from the environment (Henken et al., 1992). Therefore, the estimated increase in prevalence is 3.0%.

[8] *Escerhichia coli* is assumed to colonize the intestines of all chickens, among other organ systems. The number of chickens in the flock that suffer from symptoms is unknown.

[9] No change in prevalence assumed due to a decrease of colony-forming unit (CFU) counts in the environment, a lower stocking density, and less dust; however, they do result in a lower impact of the disease.

[10] The number of *E. coli* bacteria increases due to stagnant water in the free-range area, which results in a greater impact of the disease.

[11] Hermans and Morgan, 2007

[12] Free-range area: 28% of the wild birds' feces is infected (Craven et al., 2000). Therefore, the estimated increase compared with the situation with-out free-range area is 28%.

[13] Fanatico et al., 2008 and van Horne et al., 2003

[14] Free-range and lower stocking density (van Horne et al., 2003).

[15] Slow-growing breed and outdoor access (Fanatico et al., 2008). Effect of daylight is ignored, because leg problems decrease even further due to a longer dark period (Knowles et al., 2008). The effect of stocking density is ignored because the likelihood of having leg problems decreases even further due to a lower stocking density.

[16] Maxwell and Robertson, 1998

[17] The prevalence in case of slow-growing breed is 0. The prevalence in case of a slower-growing breed is assumed to be between 0 and the value of fast-growing breed used in conventional system (1.7). Effect of free-range access: unknown. Natural day-night regimen: increase of 0.6% (Maxwell and Robertson, 1998).

[18] Slow-growing breed: no occurrence of ascites in case of a slow-growing breed (Scheele et al., 2005).

[19] Maxwell and Robertson, 1998

[20] Free-range access results in a decrease in mortality due to sudden death syndrome (SDS; van Horne et al., 2003). The prevalence of SDS is assumed to decrease as well due to the provision of free-range area.

[21] No SDS in case of slow-growing breed. Natural day-night regimen and provision of free-range area reduces the prevalence of SDS even further (Havenstein et al., 1994; van Horne et al., 2003; Brickett et al., 2007).

Table 6.5 Effect of diseases on production performance under different animal welfare (AW) concepts compared with the healthy baseline situation (bolded data indicate that under particular AW concepts the effect of the disease is changed compared with the conventional system)

Production system/disease	Input variable				
	Mortality (% flock)	Daily weight gain (g/day)	Weight at delivery (g)	Feed conversion ratio (g/g)	Condemnation rate at slaughter (% flock)
Conventional					
Baseline situation	4.00[1]	54.88[1]	2,250[1]	1.75[1]	0.00
Infectious bronchitis (IB)	5.00[2]	52.38[2,3]	2,193[2]	1.75[2]	0.50[4]
Infectious bursal disease (IBD)	4.12[5]	52.50[3]	2,205[6]	1.77[6]	0.00
Coccidiosis	4.00[7,8]	51.99[7,8]	2,080[9]	1.87[7,8]	0.00
Coccidiosis with preventive drugs	4.00[7,8]	53.70[7,8,10]	2,008[10]	1.82[10]	0.00
Escherichia coli	4.44[11]	51.62[3]	2,168[12]	1.88[12]	0.00
Necrotic enteritis (NE)	4.82[13]	52.90[3]	2,222[13]	1.82[13]	1.36[13]
Leg problems	4.91[14,15]	44.00[16]	1,848[17]	1.78[18]	0.30[14]
Ascites	4.66[1]	54.88	2,250	1.75	0.26[19]
Sudden death syndrome (SDS)	4.22[1]	54.88[20]	2,250[20]	1.75[20]	0.00
Volwaard					
Baseline situation	1.50[1]	41.07[21]	2,300[22]	2.09[22]	0.00
IB	**1.59[1]**	29.98[2]	2,243[2]	**2.09[2]**	0.50[4]
IBD	**1.62[23]**	40.25[21]	2,254[6]	2.11[6]	0.00
Coccidiosis	1.50[7,8]	**38.92[24]**	**2,180[9]**	**2.21[25]**	0.00
Coccidiosis with preventive drugs	1.50[7,8]	**40.21[24]**	**2,252[10]**	**2.16[10]**	0.00
E. coli	**1.59[11]**	**40.77[21]**	**2,283[26]**	**2.15[26]**	0.00
NE	2.32[13]	40.57[21]	2,272[13]	2.16[13]	1.36[13]
Leg problems	**1.50[1]**	**34.00[16]**	**2,151[16]**	**2.11[18]**	0.30[14]
Ascites	**1.57[1]**	41.07	2,300	2.09	**0.05[19]**
SDS	**1.54[1]**	41.07[20]	2,300[20]	2.09[20]	0.00
Better Life 1*/Puur en Eerlijk					
Baseline situation	1.50[1]	41.07[21]	2,300[22]	2.09[22]	0.00
IB	1.59[1]	29.98[2]	2,243[2]	2.09[2]	0.50[4]
IBD	1.62[23]	40.25[21]	2,254[6]	2.11[6]	0.00
Coccidiosis	1.50[7,8]	38.92[24]	2,180[9]	2.21[25]	0.00
Coccidiosis with preventive drugs	1.50[7,8]	40.21[24]	2,252[10]	2.16[10]	0.00
E. coli	1.59[11]	40.77[21]	2,283[26]	2.15[26]	0.00
NE	2.32[13]	40.57[21]	2,272[13]	2.16[13]	1.36[13]
Leg problems	1.50[1]	34.00[16]	2,151[16]	2.11[18]	0.30[14]
Ascites	1.57[1]	41.07	2,300	2.09	0.05[19]
SDS	1.54[1]	41.07[20]	2,300[20]	2.09[20]	0.00

Continued

Table 6.5 (Continued) Effect of diseases on production performance under different animal welfare (AW) concepts compared with the healthy baseline situation (bolded data indicate that under particular AW concepts the effect of the disease is changed compared with the conventional system)

	Input variable				
Production system/disease	Mortality (% flock)	Daily weight gain (g/day)	Weight at delivery (g)	Feed conversion ratio (g/g)	Condemnation rate at slaughter (% flock)
Better Life 2*					
Baseline situation	1.50^{1}	37.50^{21}	2,100^{22}	2.15^{22}	0.00
IB	**1.59^{1}**	32.11^{2,21}	2,043^{2}	2.15^{2}	0.50^{4}
IBD	**1.62^{23}**	36.75^{21}	2,058^{6}	2.17^{6}	0.00
Coccidiosis	1.50^{7,8}	**35.92^{24}**	**2,012^{9}**	**2.27^{25}**	0.00
Coccidiosis with preventive drugs	1.50^{7,8}	**37.21^{24}**	**2,084^{10}**	**2.22^{10}**	0.00
E. coli	**1.59^{11}**	**36.45^{21}**	**2,041^{26}**	**2.21^{26}**	0.00
NE	2.32^{13}	37.00^{21}	2,072^{13}	2.22^{13}	1.36^{13}
Leg problems	**1.50^{1}**	**32.92^{16}**	**1,951^{16}**	**2.17^{18}**	0.30^{14}
Ascites	**1.57^{1}**	37.50	2,100	2.15	**0.05^{19}**
SDS	**1.54^{1}**	37.50^{20}	2,100^{20}	2.15^{20}	0.00
Better Life 3*/Skal					
Baseline situation	3.00^{27}	34.57^{21}	2,800^{27}	2.75^{27}	0.00
IB	**3.09^{1}**	25.55^{2}	2,743^{2}	2.75^{2}	0.50^{4}
IBD	**3.12^{23}**	33.88^{28}	2,744^{6}	2.78^{6}	0.00
Coccidiosis	3.00^{7,8}	**30.25^{24}**	**2,450^{9}**	**2.87^{25}**	0.00
Coccidiosis with preventive drugs	**3.00^{11}**	**31.23^{28}**	**2,530^{29}**	**2.84^{29}**	0.00
E. coli	**3.09^{11}**	**34.16^{28}**	**2,767^{26}**	**2.88^{26}**	0.00
NE	3.82^{13}	34.22^{28}	2,772^{13}	2.82^{13}	1.36^{13}
Leg problems	**3.00^{1}**	**31.00^{16}**	**2,651^{16}**	**2.76^{18}**	0.30^{14}
Ascites	**3.00^{1}**	34.57	2,800	2.75	**0.00^{19}**
SDS	**3.00^{1}**	34.57^{20}	2,800^{20}	2.75^{20}	0.00
Organic					
Baseline situation	2.80^{27}	37.14^{21}	2,600^{27}	2.63^{27}	0
IB	**2.89^{1}**	36.16^{2,30}	2,453^{2}	2.63^{2}	0.5^{4}
IBD	**2.97^{1,2}**	36.40^{30}	2,548^{6}	2.66^{6}	0.00
Coccidiosis	2.80^{7,8}	**31.50^{24}**	**2,205^{9}**	**2.75^{25}**	0.00
Coccidiosis with preventive drugs	2.80^{11}	**32.64^{28}**	**2,285^{29}**	**2.72^{29}**	0.00
E. coli	**3.89^{11}**	**36.67^{30}**	**2,567^{26}**	**2.76^{26}**	0.00
NE	3.62^{13}	36.74^{30}	2,572^{13}	2.70^{13}	1.36^{13}
Leg problems	**2.80^{1}**	**33.00^{16}**	**2,451^{16}**	**2.64^{18}**	0.30^{14}
Ascites	**2.80^{1}**	37.14	2,600	2.63	**0.00^{19}**
SDS	**2.80^{1}**	37.14^{20}	2,600^{20}	2.63	**0.00^{19}**

Continued

Table 6.5 (Continued) Effect of diseases on production performance under different animal welfare (AW) concepts compared with the healthy baseline situation (bolded data indicate that under particular AW concepts the effect of the disease is changed compared with the conventional system)

[1] van Horne et al., 2003

[2] Mortality increases by 25%, daily weight gain decreases by 27%; weight at delivery decreases by 57 g; no effect on feed conversion (Yohannes et al., 2012). No difference in impact under AW concepts.

[3] Calculated based on weight at delivery: growth/g per d = weight at delivery/42 days.

[4] Condemnation rate of 0.5%. No change is assumed under AW concepts (Lasher and Shane, 1994).

[5] Mortality increases by 3% in conventional systems (Müller et al., 2003).

[6] Weight at delivery is 2% less; feed conversion increases by 1% (McIlroy et al., 1989).

[7] No mortality due to coccidiosis; daily growth decreases by 1.32 g; weight at delivery is 100 g less, feed conversion increases by 0.1 (Voeten et al., 1988).

[8] No mortality due to coccidiosis; daily growth decreases by 5%; feed conversion increases by 2% (Graat et al., 1998).

[9] Weight at delivery under coccidiosis = average growth/g per day × production days.

[10] Due to coccidiostat, weight at delivery improved to 72 g and the feed conversion decreased by 0.05 compared with the situation in which no vaccination was applied (Wheelhouse et al., 1985).

[11] Mortality under conventional system is 0.26 to 0.62. The average of the 2 seasons is 0.44 (van Horne et al., 2003). Mortality under the AW concept is 0.09.

[12] Weight at delivery in conventional system is 83 g less; feed conversion was increased by 0.32 g between day 49 to 66, which suggests an increase in feed conversion for approximately 16 d. Accounting for the length of the production round in the conventional system, the feed conversion ratio is estimated at 1.88 g/g, i.e., 16 days × (1.75 g/g + 0.32 g/g) + 24 days × 17.5 g/g (Bhushan et al., 2008).

[13] Mortality increases by 0.82%; weight at delivery is 28 g less; feed conversion increases 0.071, condemnation rate is 1.36% (Lovland and Kaldhusdal, 2001). Under AW concepts, the same effect is assumed as in conventional systems.

[14] Increase in mortality due to leg problems is 0.8%; condemnation rate is 0.3% (Verma, 2007).

[15] Increase in mortality is 1.1% (Sullivan, 1994).

[16] In the study of Yalçin et al. (1998) the daily growth was 7 g less due to leg problems. Hereby, chickens without are compared with those with gait score (GS) 1. The effect in case of GS greater than 3 can be higher, which is also assumed in this study. A decrease in daily growth of 7 g is applied in case of Volwaard, Better Life 1*, and Better Life 2*. The decrease for conventional systems is assumed to be 10 g/d. The decrease for organic and Better Life 3* is assumed to be 4 g/d. Due to the provision of a free-range area, a slower-growing breed, a lower stocking density, and a natural day-night regimen, the number of birds with GS 4 and 5 decreases.

Continued

Table 6.5 (Continued) Effect of diseases on production performance under different animal welfare (AW) concepts compared with the healthy baseline situation (bolded data indicate that under particular AW concepts the effect of the disease is changed compared with the conventional system)

[17] The effect on daily growth is the same for the rest of the production round, which means that the weight at delivery is calculated by multiplying the daily growth by the number of production days.

[18] Chickens with leg problems eat the same quantity (Weeks et al., 2000). However, these chickens lose weight, which results in a higher feed conversion. Su et al. (1999) calculated the feed conversion for chickens with and without GS 4 and 5. The average feed conversion for chickens with GS 4 and 5 was 0.03 lower than that in the situation without leg problems. With improved welfare, the severity of leg problems decreases. It is assumed that leg problems are the most severe in the conventional system, which indicates that leg problems have the highest effect on feed conversion in conventional systems (feed conversion is lower with 0.03). In Volwaard, Better Life 1*, and Better Life 2*, the feed conversion was 0.02 lower and in Better Life 3* and organic systems it was 0.01 lower compared with the situation without leg problems.

[19] Condemnation rate for conventional is 0.26%. Condemnation rate for AW concepts is 0.05%. However, no ascites are assumed for organic and Better Life 3* systems, which means that the condemnation rate under these concepts is zero (Herenda and Jakel, 1994).

[20] No effect apart from mortality (Julian, 2005).

[21] Calculated based on weight at delivery: growth/g per d = weight at delivery/56 days.

[22] Ellen et al., 2012

[23] Mortality due to IBD increases similarly under AW and conventional systems (+0.12). This results in a relative increase in mortality due to IBD, which corresponds to the findings of van Horne et al. (2003).

[24] Voeten et al. (1988) found that chickens could recover from an infection of coccidiosis in 35 days, which means that its effect on performance was eliminated. It is assumed that the chicken grows at a slower rate for 35 days, and for the rest of production period, a healthy growth rate is calculated. The following formula calculates the average growth: average growth/g per d = [35 days recovery × (growth healthy – negative effect coccidiosis) + rest of the production period × growth healthy]/total production days. Under Volwaard, Better Life 1*, and Better Life 2*, the daily growth decreases by 4 g/d lower during the recovery period of 35 days. Under Better Life 3* and organic, the daily growth decreases by 11 g/day, because the free-range area infection with coccidiosis and the probability of picking up more oocysts increase.

[25] Subclinical coccidiosis is primarily expected in a conventional system. A light infection level is assumed in Volwaard, Better Life 1*, and Better Life 2* because the chickens have access to free range. A moderate infection level is assumed in Better Life 3* and organic systems because the use of anticoccidial drugs is prohibited (Reid and Johnson, 1970; Voeten et al., 1988).

Continued

Table 6.5 (Continued) Effect of diseases on production performance under different animal welfare (AW) concepts compared with the healthy baseline situation (bolded data indicate that under particular AW concepts the effect of the disease is changed compared with the conventional system)

[26] Effect of *E. coli* is decreased due to a lower stocking density, breed, and fewer stress factors. However, there is an increase due to the free-range area. The relative decrease in mortality is calculated (80%) according to van Horne et al. (2003). The effect under the AW concepts is decreased by 80% compared with that under conventional system. However, in case of organic and Better Life 3* concepts, the free-range area is not covered and the water may remain there, which could serve as a good reserve for *E. coli*. Therefore, the effect of *E. coli* for these concepts is decreased by 60%.

[27] Vermeij and van Horne, 2008

[28] Calculated based on weight at delivery: growth/g per day = weight at delivery/81 days.

[29] Due to vaccination against coccidiosis, weight at delivery improved to 80 g and the feed conversion decreased by 0.03 compared with the situation in which no vaccination was applied (Vermeulen et al., 2001).

[30] Calculated based on weight at delivery: growth/g per day = weight at delivery/70 days.

Table 6.6 Economic inputs by different production systems

	Production system					
Input variable	Conventional	Volwaard	Better Life 1*/Puur en Eerlijk	Better Life 2*	Better Life 3*/Skal	Organic
Feed price[1] (€/100 kg)	31.839	30.883	30.883	30.883	45.211	45.211
Price of day-old chick[1] (€/chick)	0.302	0.320	0.320	0.320	0.438	0.438
Litter[1] (€/chicken)	0.008	0.030	0.028	0.026	0.040	0.040
Product board levies[2] (€/100 chickens)	0.290	0.290	0.290	0.290	0.290	0.290
Carrion collecting service[2] (€/100 chickens)	0.200	0.200	0.200	0.200	0.200	0.200
Manure disposal[2] (€/100 chickens)	2.400	2.400	2.400	2.400	2.400	2.400
Labor cost[2] (h)	25.00	25.00	25.00	25.00	25.00	25.00
Electricity[1] (€/chicken)	0.023	0.023	0.023	0.023	0.012	0.012
Heating[1] (€/chicken)	0.045	0.068	0.068	0.068	0.090	0.090
Coccidiostat[3] (€/chicken)	0.007	0.007	0.007	0.007	0.007	0.007
Vaccination coccidiosis[4] (€/chicken)	0.120	0.120	0.120	0.120	0.120	0.120
Vaccination IBD[5] (€/chicken)	0.010	0.010	0.010	0.020	0.020	0.020
Re-vaccination IB[5] (€/chicken)	0.010	0.010	0.010	0.010	0.010	0.010
Antibiotic treatment NE and *Escherichia coli*[3,6] (€/chicken)	0.027	0.027	0.027	0.027	0.027	0.027
Fixed costs[2] (%)						
Depreciation of buildings	4	4	4	4	4	4
Depreciation inventory	8	8	8	8	8	8
Interest	5	5	5	5	5	5
Interest livestock	6	6	6	6	6	6
Maintenance of buildings	1	1	1	1	1	1
Maintenance inventory	2	2	2	2	2	2
Maintenance outdoor access	2	2	2	2	2	2

[1] Gocsik et al., 2013

[2] KWIN-V, 2011

[3] Puister, 2009. NE = necrotic enteritis.

[4] Steenhuisen and Vossen, 2001.

[5] Standard tariff for Dutch veterinarians. IBD = infectious bursal disease; IB = infectious bronchitis.

[6] PVE, 2011

Sensitivity Analysis

Feed price in the broiler sector is highly volatile, which can have a significant effect on the economic performance of the farm. Moreover, the inputs are based on literature and can vary greatly under farm conditions. Therefore, a sensitivity analysis was conducted to evaluate the robustness of the results. The sensitivity analysis was restricted to diseases with the highest economic effect; that is, coccidiosis, *E. coli*, and NE. Feed costs and purchase of one-day-old chicks are the main drivers of costs (Castellini et al., 2012). Changes in the purchase price of one-day-old chicks may influence costs through mortality and condemnation at slaughter. Therefore, the feed price, the feed conversion rate, and the purchase price of one-day-old chicks were systematically varied one at a time. Feed price was changed by±5%, feed conversion by ±0.1, and purchase price of one-day-old chicks by ±5%.

Results

Absolute Effect of Various Diseases on Production Costs

Table 6.7 presents the absolute effect of various diseases on production costs. During the calculation of production costs, one disease was considered at a time and no interaction effect between diseases was assumed. Production costs in the baseline situation (no diseases) differed across systems. With regard to production costs, 3 categories emerged. The first category included the conventional system with the lowest production costs. The second category, which included Volwaard, Better Life 1*, and Better Life 2* (also referred to as middle-market systems), produced costs that were higher than the conventional system, but considerably lower than systems in the third category, which included Better Life 3* and organic.

In the conventional system, diseases that affect the gastrointestinal tract (that is, *E. coli* and NE) had the highest absolute effect on production costs. Production costs per delivered broiler increased by €0.144 in case of *E. coli* and by €0.071 in case of NE. The other diseases had a minor effect on production costs. Similarly, in case of the second category, *E. coli* and NE again had the highest effect on production costs, whereas, in the third category, coccidiosis had the highest effect, followed by *E. coli* and NE. The high effect of coccidiosis can be explained by the fact that the use of anticoccidial drugs is prohibited in organic systems. The absolute effect of gastrointestinal problems on production costs remained at the same level or even increased with more welfare-friendly production. However, the absolute effect of leg problems and heart and vascular disease decreased for AW systems because these systems use a more robust breed.

Relative Effect of Various Diseases on Production Costs

Table 6.8 shows the relative effect of various diseases on production costs. Again, the same 3 categories emerged as in the case of absolute effect. In the conventional system, the highest relative effect was caused by gastrointestinal diseases corresponding to approximately 11.5%, which was the sum of separate effects (i.e., coccidiosis = 1.24%, *E. coli* = 6.8%, NE = 3.39%), followed by leg problems. The dominance of gastrointestinal diseases in terms of relative effect can be recognized in all systems. In the second category (which included Volwaard, Better Life

Table 6.7 Production costs per delivered broiler in the baseline situation and situation with an endemic disease and absolute effect on production costs compared with the baseline situation (€)

Diseases	Production systems											
	Conventional		Volwaard		Better Life 1*/ Puur en Eerlijk		Better Life 2*		Better Life 3*/ Skal		Organic	
	Production cost	Absolute impact	Production cost	Absolute impact	Production cost	Absolute impact	Production cost	Absolute impact	Production cost	Absolute impact	Production cost	Absolute impact
Baseline situation	2.094	0.000	2.586	0.000	2.700	0.000	2.614	0.000	6.075	0.000	5.291	0.000
Respiratory												
IB	2.104	0.010	2.596	0.010	2.710	0.010	2.624	0.010	6.085	0.010	5.301	0.010
Immune organs												
IBD	2.104	0.010	2.596	0.010	2.710	0.010	2.634	0.020	6.095	0.020	5.311	0.020
Gastrointestinal												
Coccidiosis	2.120	0.026	2.630	0.044	2.746	0.046	2.652	0.039	6.320	0.245	5.522	0.232
E.coli	2.238	0.144	2.661	0.075	2.776	0.076	2.699	0.086	6.291	0.215	5.522	0.231
NE	2.165	0.071	2.672	0.087	2.787	0.087	2.697	0.083	6.222	0.147	5.429	0.138
Locomotion												
Leg problems	2.119	0.025	2.595	0.009	2.709	0.009	2.622	0.008	6.075	0.000	5.291	0.000
Heart and vascular												
Ascites	2.107	0.013	2.588	0.002	2.703	0.003	2.617	0.003	6.075	0.000	5.291	0.000
SDS	2.098	0.004	2.586	0.001	2.701	0.001	2.615	0.001	6.075	0.000	5.291	0.000

1*, and Better Life 2*), the relative effect of gastrointestinal diseases was lower (approximately 8%) than in the conventional system. In the third category, however, their relative effect was almost at the same level as that in the conventional system. The effect of leg problems decreased with increasing AW standards. The relative effect of other diseases remained below 1% in all systems, which meant they were less important in that regard.

Table 6.8 Relative effect of various diseases on production costs per delivered broiler (%)

Diseases	Production systems					
	Conventional	Volwaard	Better Life 1*/ Puur en Eerlijk	Better Life 2*	Better Life 3* /Skal	Organic
Baseline situation	0.00	0.00	0.00	0.00	0.00	0.00
Respiratory						
IB[1]	0.48	0.39	0.37	0.38	0.16	0.19
Immune organs						
IBD[1]	0.48	0.39	0.37	0.77	0.33	0.38
Gastrointestinal						
Coccidiosis	1.24	1.70	1.68	1.48	4.03	4.38
E.coli	6.86	2.89	2.80	3.28	3.54	4.37
NE[1]	3.39	3.25	3.22	3.18	2.42	2.61
Locomotion						
Leg problems	1.19	0.35	0.33	0.31	0.00	0.00
Heart and vascular						
Ascites	0.61	0.10	0.09	0.11	0.00	0.00
SDS[1]	0.19	0.02	0.02	0.04	0.00	0.00

[1] IB = infectious bronchitis; IBD = infectious bursal disease; NE = necrotic enteritis; SDS = sudden death syndrome.

Proportion of Health Care Costs in Total Production Costs

Table 6.9 lists the health care costs due to gastrointestinal diseases and leg problems as a percentage of total production costs. These diseases were selected because they had the highest relative effect on production costs (as shown in Table 6.8). Health care costs were split into *L* and *E* and presented as percentage shares of the total production costs. As Table 6.9 shows, health care costs represent only a small share of total production costs in all systems. In conventional and middle-market systems, the proportion of loss within total health care costs is approximately 3 times greater than the proportion of expenditures. In Better Life 3* and organic systems, the proportion of loss is approximately 90% of the total health care costs. However, in case of coccidiosis, health care costs were solely derived from loss (100%) in these 2 systems, whereas in conventional systems, 73% of health care costs came from loss. This larger loss due to coccidiosis in Better Life 3* and organic systems occurred because the use of anticoccidal drugs was prohibited, which meant that procuring them incurred no expenditures.

In general, the proportion of loss in total health care costs is larger than that of expenditures. Because the symptoms of gastrointestinal diseases remain subclinical, these diseases usually remain untreated. For example, a less efficient feed conversion due to a gastrointestinal disease results in a higher feed consumption and, ultimately, in higher feed costs. This implies that it is more difficult to detect the actual effect of these diseases because they are not incurred as direct expenditures. The loss due to leg problems decreased in the middle-market systems due to increasing AW standards. In the organic system, no health care costs occurred due to leg problems.

Table 6.9 Proportion of health care costs within the total production costs (%). Proportion of loss and expenditures expressed as percentage in total production costs

	Production systems					
Diseases	Conventional	Volwaard	Better Life 1*/ Puur en Eerlijk	Better Life 2*	Better Life 3* /Skal	Organic
Gastrointestinal						
Coccidiosis[1]	1.22	1.68	1.65	1.46	3.88	4.20
Loss(L)	*0.89*	*1.42*	*1.41*	*1.20*	*3.88*	*4.20*
Expenditures (E)	*0.33*	*0.26*	*0.24*	*0.26*	-	-
E.coli[1]	6.42	2.81	2.72	3.18	3.42	4.19
Loss(L)	*5.22*	*1.81*	*1.77*	*2.18*	*2.99*	*3.70*
Expenditures (E)	*1.21*	*1.00*	*0.96*	*1.00*	*0.43*	*0.49*
NE[1]	3.28	3.24	3.12	3.08	2.36	2.55
Loss(L)	*2.04*	*2.24*	*2.17*	*2.08*	*1.93*	*2.05*
Expenditures (E)	*1.25*	*0.99*	*0.95*	*1.00*	*0.43*	*0.50*
Locomotion						
Leg problems[1]	1.18	0.34	0.33	0.31	0.00	0.00
Loss(L)	*1.18*	*0.34*	*0.33*	*0.31*	-	-
Expenditures (E)	-	-	-	-	-	-

[1] C = L + E. Health care costs consists of loss (L) caused by diseases and the preventive and treatment expenditures

Sensitivity Analysis

Because it was of great importance that the ranking of production systems for various diseases is robust to changes in input values, changes in relative effect were studied. Accordingly, we analyzed changes in the sequence from the highest to the lowest relative effect. Table 6.10 shows that irrespective to changes in the variables included in the analysis, coccidiosis had the highest relative effect in the organic system and the lowest relative effect in the conventional system. *Escherichia coli* had the highest relative effect in the conventional system and the lowest effect in the Better Life 1* system. Similarly, NE had the highest relative effect in the conventional system and the lowest effect in the Better Life 3* system under all of the examined conditions. Overall, the results indicated that changes in feed price, feed conversion, and purchase price of one-day-old chicks had no effect on the sequence from the highest to the lowest relative effect.

Table 6.10 Relative effect of various diseases on production costs per delivered broiler in case of changes in feed price, feed conversion ratio, and price of one-day-old chicks (%)

		Production systems					
Diseases	Change in variable	Conventional	Volwaard	Better Life 1*/ Puur en Eerlijk	Better Life 2*	Better Life 3*/Skal	Organic
	Feed price						
Baseline situation	-5%	0.00	0.00	0.00	0.00	0.00	0.00
	0%	0.00	0.00	0.00	0.00	0.00	0.00
	5%	0.00	0.00	0.00	0.00	0.00	0.00
Coccidiosis	-5%	1.23	1.71	1.72	1.42	4.06	4.42
	0%	1.24	1.70	1.70	1.45	4.03	4.37
	5%	1.30	1.69	1.73	1.42	3.95	4.33
E.coli	-5%	6.86	2.91	2.78	3.23	3.51	4.36
	0%	6.86	2.90	2.81	3.25	3.56	4.37
	5%	6.92	2.90	2.78	3.21	3.57	4.39
NE[1]	-5%	3.50	3.43	3.28	3.27	2.47	2.69
	0%	3.39	3.33	3.22	3.18	2.42	2.61
	5%	3.39	3.27	3.14	3.09	2.35	2.55
	Feed conversion ratio						
Baseline situation	-0.1	0.00	0.00	0.00	0.00	0.00	0.00
	0	0.00	0.00	0.00	0.00	0.00	0.00
	+0.1	0.00	0.00	0.00	0.00	0.00	0.00
Coccidiosis	-0.1	1.34	1.75	1.71	1.45	4.12	4.49
	0	1.24	1.70	1.70	1.45	4.03	4.37
	+0.1	1.20	1.66	1.62	1.38	3.95	4.31
E.coli	-0.1	7.17	2.98	2.85	3.33	3.61	4.49
	0	6.88	2.90	2.81	3.25	3.56	4.37
	+0.1	6.60	2.79	2.71	3.13	3.47	4.29
NE	-0.1	3.51	3.42	3.27	3.26	2.47	2.69
	0	3.39	3.33	3.22	3.18	2.42	2.61
	+0.1	3.28	3.24	3.14	3.10	2.37	2.57

Continued

Table 6.10 (Continued) Relative effect of various diseases on production costs per delivered broiler in case of changes in feed price, feed conversion ratio, and price of one-day-old chicks (%)

		Production systems					
Diseases	Change in variable	Conventional	Volwaard	Better Life 1*/ Puur en Eerlijk	Better Life 2*	Better Life 3*/Skal	Organic
	Price day-old chicks						
Baseline situation	-5%	0.00	0.00	0.00	0.00	0.00	0.00
	0%	0.00	0.00	0.00	0.00	0.00	0.00
	5%	0.00	0.00	0.00	0.00	0.00	0.00
Coccidiosis	-5%	1.25	1.71	1.68	1.42	4.05	4.38
	0%	1.24	1.70	1.70	1.45	4.03	4.37
	5%	1.23	1.69	1.66	1.41	4.02	4.35
E.coli	-5%	6.88	2.92	2.83	3.27	3.55	4.37
	0%	6.88	2.90	2.81	3.25	3.56	4.37
	5%	6.78	2.88	2.76	3.19	3.53	4.35
NE	-5%	3.42	3.35	3.24	3.19	2.41	2.60
	0%	3.39	3.33	3.22	3.18	2.42	2.61
	5%	3.36	3.31	3.20	3.15	2.41	2.60

[1] NE = necrotic enteritis.

Discussion

The aim of the study was to analyze the effect of different broiler production systems on readily quantifiable health care costs, which were calculated per delivered broiler using partial budgeting. A model described by Gocsik et al. (2013) was used and adapted to calculate health care costs in Dutch broiler production systems.

Although the approach used in our study draws heavily on input data that were not available in peer-reviewed scientific literature, all input data were gathered with care and thoroughly checked with an expert in poultry diseases to be able to provide the most accurate results.

The approach used in our study involved certain approximations and assumptions. First, own labor cost was assumed to be fixed. A farm was assumed to have as many animal places as can be managed by one FTE. When diseases occur, the activities on the farm may require more time than the farmer has available and extra personnel may have to be hired, potential causing health care costs to increase. The literature on time spent on treatment and hygiene measures as a consequence of a disease occurrence is scarce. The broiler farmer was assumed to have time available to perform these activities. Second, the default values used in this study, such as weight at delivery and feed conversion rate, were averages representing the Netherlands and thus country specific. It is unknown whether and to what extent these values were influenced by diseases. No corrections were made in this respect, which means that these values may differ in practice. However, this assumption is not expected to influence the results considerably because it was valid for all systems. Further, only the direct disease effects were taken into account, in other words the possible immunosuppressive effect of some diseases was not considered. Third, no interactions were assumed between diseases because, for most diseases, it is still unclear whether and to what extent the effect of the diseases changes in case 2 endemic diseases simultaneously occur in the flock (Cavanagh, 2003; Matthijs et al., 2003). Fourth, we assumed that vaccination against IB and IBD would protect the flock 100% and that these diseases would no longer occur on the farm. In case of IBD, however, the hygienic status of the farm is known to influence the effectiveness of the vaccine (Müller et al., 2012). Moreover, little is known about whether the vaccine offers cross-protection against other serotypes. A farm with an outdoor area for chickens is expected to have a lower level of hygiene, which negatively affects the effectiveness of the vaccine. Moreover, chickens in an organic farm have more antibodies against IBD than chickens in conventional farms (van Overbeke et al., 2006). Hence, in case of farms with Better Life 2*, Better Life 3*, and organic systems, which have an increased risk of IBD, a more expensive vaccination program was assumed to be implemented. Because a vaccine against IB may not provide 100% protection either (Cavanagh, 2003), chickens were assumed to be vaccinated twice. The study investigates the health care costs of the preventive measures, not the economic feasibility. In other words, if vaccination prevented great losses, it was chosen as a preventive measure. Fifth, the chickens were assumed to be equally susceptible and sensitive to the diseases throughout the entire growth period. The effect of current breeder health programs is implicitly taken into account, because the prevalence and effect of diseases were determined based on the current production systems and the characteristics of breeds currently used in practice. This model does not take potential resistance against preventive drugs and antibiotics into account. However, coccidiosis is known to be more and more resistant against anticoccidial drugs, which mitigates the negative effects of diseases to a lesser extent (Jenkins et al., 2010). Hence, avoidable costs might be lower than those estimated in the model. Resistance to drugs against NE and *E. coli* has also been increasing. In each system, the same amount of drugs was assumed to be used. The study did not include the potential effect of a particular disease in previous and subsequent production rounds. Sixth, health care costs may have been overestimated to some extent. A disease has an effect on the production function, and therefore on the optimal production level (McInerney, 1996). An economically rational farmer would minimize the effect of a disease by adjusting the level of input use, which would probably result in health care costs lower than those estimated in this study. Finally, figures for prevalence and effect might not entirely reflect the latest developments in broiler production. For example, in recent years the incidence of ascites has reduced due to including ascites in the selection index; however, recent figures cannot be found in literature. As a consequence, the actual values for prevalence may be lower than those we used in our calculation. However, this holds for all systems. Therefore, the differences between systems remain similar. In other words, whereas actual costs due to ascites may be lower, the relative differences between systems remain unchanged. Moreover, due to various assumptions and estimations, production costs may be under- or overestimated. Therefore, it is important that these costs are not used as indicators, but to comprehensively assess the differences between systems. Sensitivity analysis showed that ranking of production systems is robust to changes in feed price, feed conversion, and price of one-day-old chicks.

To our knowledge, this study is the most extensive attempt to compare AW systems on the basis of their health care costs. The results of the study show that health care costs represent only a small proportion of total production costs, regardless of the production system. Losses account for the majority of health care costs, which makes the actual effect of diseases on total health care costs difficult to detect. Three categories of production systems were distinguished based on health care costs. The first category includes conventional systems, in which diseases affecting the gastrointestinal tract and leg problems had the highest effect on production costs in both absolute and relative terms. Similarly, in the second category, referred to as middle-market systems, gastrointestinal diseases and leg problems had the highest effect on production costs. However, the effect of these diseases was lower than that of diseases in conventional system. The decrease in effect can be explained by the fact that these AW systems use a more robust breed with a slower growth rate. In the third category, gastrointestinal diseases had the highest effect and the overall effect of gastrointestinal diseases was similar to that in the conventional system. However, the effect of coccidiosis increased compared with the conventional system, most likely due to prohibition on the use of anticoccidial drugs and the provision of an outdoor access. Moreover, leg problems and heart and vascular diseases disappeared completely, which is probably the result of the use of a more robust breed with a slower growth rate. Angel (2007) suggested that chickens with slower early growth rate have less problems with skeletal development. Also, research indicated that there was a direct correlation between high growth rate and ascites (European Commission, 2000).

There are only a few studies against which to compare our results. Vermeij (2004) and Vermeij and van Horne (2008) calculated cost-prices for organic broiler farms in 2004 and in 2008. The total health care costs were estimated at €0.12 per broiler in 2004 and €0.10 per broiler in 2008. These estimates do not agree with the results of this study, in which the absolute health care costs are often higher than €0.10 per delivered broiler in an organic farm. Lovland and Kaldhusdal (2001) found that the profit margin decreased by 33% in case of high levels of NE in the flock compared with low levels of the disease. Moreover, the absolute costs due to NE in the United States were estimated at US$0.05 per broiler chicken (McDevitt et al., 2006). In another American study, the loss ranged between $878.19 and $1,480.52 per flock of 20,000 broilers. This works out to an estimated $0.044 to 0.074 per chicken (Skinner et al., 2010), which, based on exchange rates at the time of writing, equates to approximately €0.03 to 0.06 per broiler. This is in agreement with the results of the conventional system. However, these costs are much higher in Better Life 3* and organic systems. Lund and Algers (2003) supported the findings of this study. Based on a literature study, they concluded that the level of animal health in an organic farm was the same or slightly lower level than in a conventional system, except for (endo)parasitic infections, which occurred more often in an organic farm. The occurrence of other diseases remained at the same level or decreased compared with a conventional system. This difference can also be found in the results of the present study. In other words, the occurrence of parasitic infections, such as coccidiosis, increases compared with a conventional system, whereas the occurrence of other diseases, such as leg problems, SDS, and ascites, decreases.

Although the study focused on the Dutch situation, the findings are relevant for countries that face similar concerns with respect to AW than the Netherlands (for example, other European Union countries and United States) and develop their production in a similar direction than the Netherlands (for example, France and United Kingdom; Gocsik et al., 2013).

Although we observed that particular health care costs increase as the assumed level of AW increases, this finding does not apply to all diseases. We conclude that, although differences in health care costs exist across production systems, health care costs have only a minor role within the total production costs relative to other costs, such as feed costs and purchase of one-day-old chicks. Therefore, the effect of health care costs on farmers' strategic decisions regarding the production system is most likely to be outweighed by other costs.

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References

Angel, R. (2007). Metabolic disorders: Limitations to growth of and mineral deposition into the broiler skeleton after hatch and potential implications for leg problems. Journal of Applied Poultry Research, 16:138–149. DOI: http://dx.doi.org/ 10.1093/japr/16.1.138.

BCFI. (2012). Vaccinatie van kippen. Available at http://www.cbip-vet.be/nl/texts/NAVOOOL1AL2o.php#Kippen. Accessed 19-10-2012.

Bennett, R. (2003). The 'Direct Costs' of Livestock Disease: The development of a system of models for the analysis of 30 endemic livestock diseases in Great Britain. Journal of Agricultural Economics, 54:55–71. DOI: http://dx.doi.org/10.1111/j.1477-9552.2003.tb00048.x.

Bennett, R., Ijpelaar, J. (2005). Updated estimates of the costs associated with thirty four endemic livestock diseases in Great Britain: A note. Journal of Agricultural Economics, 56:135–144. DOI: http://dx.doi.org/10.1111/j.1477-9552.2005.tb00126.x.

Bergevoet, R.H.M., Bartels, J.C.M., van Der Goot, J., Wolthuis-Fillerup, M. (2010). Bedrijfsgebonden dierziekten op varkens-, rundvee en pluimveebedrijven. Inventarisatie en prioritering van de belangrijkste aandoeningen. Rapport 384. Wageningen UR Livestock Research, Lelystad, the Netherlands. Available at http://edepot.wur.nl/160695. Accessed 22-11-2013.

Bhushan, B., Garg, S.K., Kumar, J. (2008). Effect of a poly-herbal feed supplement on production performance and nutrient utilization in *Escherichia coli* challenged broiler chicks. Indian Journal of Veterinary Research, 17:27–36.

Blokhuis, H.J., Jones, R.B., Geers, R., Miele, M., Veissier, I. (2003). Measuring and monitoring animal welfare: Transparency in the food product quality chain. Animal Welfare, 12:445–455.

Brickett, K.E., Dahiya, J. P., Classen, H.L., Annett, C.B., Gomis, S. (2007). The effect of nutrient density, feed form, and photoperiod on the walking ability and skeletal quality of broiler chickens. Poultry Science, 86:2117–2125.

Brigden, J.L., Riddell, C. (1975). A survey of mortality in four broiler flocks in western Canada. Canadian Veterinary Journal, 16:194–200.

Castellini, C., Boggia, A., Cortina, C., Dal Bosco, A., Paolotti, L., Novelli, E., Mugnai, C. (2012). A multicriteria approach for measuring the sustainability of different poultry production systems. Journal of Cleaner Production, 37:192–201. DOI: http://dx.doi.org/10.1016/j. jclepro.2012.07.006.

Cavanagh, D. (1992). Recent advances in avian virology. British Veterinary Journal. 148:199–222.

Cavanagh, D. (2003). Severe acute respiratory syndrome vaccine development: Experiences of vaccination against avian infectious bronchitis coronavirus. Avian Pathology, 32:567–582. DOI: http:// dx.doi.org/10.1080/03079450310001621198.

Cook, J.K.A., Orbell, S.J., Woods, M.A., Huggins, M.B. (1999). Breadth of protection of the respiratory tract provided by different live-attenuated infectious bronchitis vaccines against challenge with infectious bronchitis viruses of heterologous serotypes. Avian Pathology, 28:477–485. DOI: http://dx.doi.org/10.1080/03079459994506.

Craven, S.E.,. Stern, N.J, Line, E., Bailey, J.S., Cox, N.A., Fedorka-Cray, P. (2000). Determination of the incidence of *Salmonella* spp., *Campylobacter jejuni*, and *Clostridium perfringens* in wild birds near broiler chicken houses by sampling intestinal droppings. Avian Diseases, 44:715–720. DOI: http://dx.doi.org/10.2307/1593118.

Cui, S., Ge, B., Zheng, J., Meng, J. (2005). Prevalence and antimicrobial resistance of *Campylobacter* spp. and *Salmonella* serovars in organic chickens from Maryland retail stores. Applied and Environmental Microbiology, 71:4108–4111.

De Jong, I., Berg, C., Butterworth, A., Estévez, I. (2012). Scientific report updating the EFSA opinions on the welfare of broilers and broiler breeders. Supporting Publications 2012:EN-295. Available at http://www.efsa.europa.eu/en/supporting/ pub/295e.htm. Accessed 22-11-2013.

De Smit, L., Tona, K., Bruggeman, V., Onagbesan, O., Hassanzadeh, M., Arckens L., Decuypere, E. (2005). Comparison of three lines of broilers differing in ascites susceptibility or growth rate, egg weight loss, gas pressure, embryonic heat production and physiological hormone levels. Poultry Science, 84:1446–1452.

Dijkhuizen, A.A., Morris, R.S. (1997). Animal health economics: Principles and applications. Post Graduate Foundation in Veterinary Science, University of Sydney, Sydney, Australia.

Dziva, F.,. Stevens, M.P. (2008). Colibacillosis in poultry: Unravelling the molecular basis of virulence of avian pathogenic *Escherichia coli* in their natural hosts. Avian Pathology, 37:355–366.

EC. (2007a). Regulation (EC) No. 834/2007, OJ L 189, p. 1 of 20.7.2007. Available at http://eur-lex.europa.eu/Lex UriServ/LexUriServ.do?uri=OJ:L:2007:189:0001:0023:EN:PDF. Accessed 25-11-2013.

EC. (2007b). Directive, 2007/43/EC, OJ L 182, p. 19 of 12.7.2007. Available at http://eur-lex.europa.eu/LexUriServ/site/ en/oj/2007/l_182/l_18220070712en00190028.pdf. Accessed 25-11-2013.

EC. (2008). Regulation (EC) No. 543/2008, OJ L 157, p. 46 of 17.6.2008. Available at http://eur-lex.europa.eu/Lex UriServ/LexUriServ.do?uri=OJ:L:2008:157:0046:0087:EN:PDF. Accessed 25-11-2013.

Ellen, H., Leenstra, F., van Emous, R., Groenestein, K., van Harn, J., van Horne, P., de Jong I., Kense, M., Mevius, D., Wagenaar, J.A. (2012). Vleeskuikenproductiesystemen in Nederland, Rapport 619 (in Dutch with English summary). Livestock Research, Wageningen University and Research Centre, Lelystad, the

Netherlands.

Estévez, I. (2007). Density allowance for broilers: Where to set limits? Poultry Science, 86:1265–1272.

European Commission. (2000). The welfare of chickens kept for meat production (broilers). Scientific Committee on Animal Health and Animal Welfare. Available at http://ec.europa.eu/food/fs/sc/scah/out39_en.pdf. Accessed 22-11-2013.

Fanatico, A. C., Pillai, P.B., Cavitt, L.C., Owens, C.M., Emmert, J.L. (2005). Evaluation of slower-growing broiler genotypes grown with and without outdoor access: Growth performance and carcass yield. Poultry Science, 84:1321–1327.

Fanatico, A.C., Pillai, P.B., Hester, P.Y., Falcone, C., Mench, J.A, Owens, C.M., Emmert, J.L. (2008). Performance, livability, and carcass yield of slow- and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. Poultry Science, 87:1012–1021. DOI: http://dx.doi.org/10.3382/ ps.2006-00424.

Fernandez, A., Lara, C., Puyuelo, R., Gomez, J., Ramos, J.J., Loste, A., Marca, M.C., Verde, M.T. (1998). Efficacy of phosphomycin in the control of *Escherichia coli* infection of broiler chickens. Research in Veterinary Science, 65:201–204.

Fraser, D. (2006). Animal welfare assurance programs in food production: A framework for assessing the options. Animal Welfare, 15:93–104.

GD. (2012). Vaccinatieschema. Available at http://www.gddeventer.com/pluimvee/voor%20dierhouders/diergezondheid/~/media/Files/pluimvee%20vaccinatieschemas/vaccina-tiekrt%20vleeskuikens.pdf.ashx. Accessed 19-10-2012.

Gilchrist, P. (2005). Involvement of free-flying wild birds in the spread of the viruses of avian influenza, Newcastle disease and infectious bursal disease from poultry products to commercial poultry. World's Poultry Science Journal, 61:198–214. DOI: http://dx.doi.org/10.1079/ WPS200451.

Gocsik, É., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2013). Mid-term financial effect of animal welfare improvements in Dutch broiler production. Poultry Science, 92:3314–3329.

Graat, E.A.M., Ploeger, H.W., Henken, A.M., de Vries Reilingh, G.,. Noordhuizen, J.P.T.M, van Beek, P.N.G.M. (1996). Effects of initial litter contamination level with *Eimeria acervulina* on population dynamics and production characteristics in broiler. Veterinary Parasitology, 65:223–232.

Graat, E.A.M., van der Kooij, E., Frankena, K., Henken, A.M., Smeets, J.F.M., Hekerman, M.T.J. (1998). Quantifying risk factors of coccidiosis in broilers using on-farm data based on a veterinary practice. Preventive Veterinary Medicine, 33:297–308. DOI: http://dx.doi. org/10.1016/S0167-5877(97)00008-1.

Haug, A., Gjevre, A.G., Skjerve, E., Kaldhusdal, M. (2008). A survey of the economic effect of subclinical

Eimeria infections in broiler chickens in Norway. Avian Pathology, 37:333–341. DOI: http:// dx.doi.org/10.1080/03079450802050705.

Havenstein, G.B., Ferket, P.R., Scheideler, S.E., Larson, B.T. (1994). Growth, livability, and feed conversion of 1957 vs 1991 broilers when fed "typical" 1957 and 1991 broiler diets. Poultry Science, 73:1785–1794. DOI: http://dx.doi.org/10.3382/ps.0731785.

Henken, A.M., Goelema, J.O., Neijenhuis, F., Vertommen, M.H., van Den Bos, J., Fris, C. (1992). Multivariate epidemiological approach to coccidiosis in broilers. Poultry Science, 71:1849–1856. DOI: http://dx.doi.org/10.3382/ps.0711849.

Herenda, D., Jakel, O. (1994). Poultry abattoir survey of carcass condemnation for standard, vegetarian, and free range chickens. Canadian Veterinary Journal, 35:293–296.

Hermans, P.G., Morgan, K.L., (2007). Prevalence and associated risk factors of necrotic enteritis on broiler farms in the United Kingdom; a cross-sectional survey. Avian Pathology, 36:43–51. DOI: http://dx.doi.org/10.1080/03079450601109991.

Homer, B.L., Butcher, G.D., Miles, R.D., Rossi, A.F. (1992). Subclinical infectious bursal disease in an integrated broiler production operation. Journal of Veterinary Diagnostic Investigation, 4:406–411. DOI: http:// dx.doi.org/10.1177/104063879200400406.

Houe, H. (2003). Economic effect of BVDV infection in dairies. Biologicals, 31:137–143. DOI: http://dx.doi.org/10.1016/S1045-1056(03)00030-7.

Jenkins, M., Klopp, S., Ritter, D., Miska, K., Fetterer, R. (2010). Comparison of *Eimeria* species distribution and Salinomycin resistance in commercial broiler operations utilizing different coccidiosis control strategies. Avian Diseases, 54:1002–1006.

Julian, R.J. (1998). Rapid growth problems: Ascites and skeletal deformities in broilers. Poultry Science, 77:1773–1780.

Julian, R.J. (2005). Production and growth related disorders and other metabolic diseases of poultry—A review. Veterinary Journal. 169:350–369. DOI: http://dx.doi.org/10.1016/j.tvjl.2004.04.015.

Kabir, S.M.L. (2010). Review: Avian colibacillosis and Salmonellosis: A closer look at epidemiology, pathogenesis, diagnosis, control and public health concerns. International Journal of Environmental Research and Public Health, 7:89–114.

Knowles, T.G., Kestin, S.C., Haslam, S.M., Brown, S.N., Green, L.E., Butterworth, A., Pope, S.J., Pfeiffer, D., Nicol, C.J. (2008). Leg disorders in broiler chickens: Prevalence, risk factors and prevention. Plos ONE, 3:e1545.

KWIN-V. (2011). Kwantitatieve Informatie Veehouderij 2011–2012. Wageningen UR Livestock Research, Lelystad, the Netherlands.

Lasher, H.N., Shane, S.M. (1994). Infectious bursal disease. World's Poultry Science Journal, 50:133–166. DOI: http://dx.doi.org/10.1079/ WPS19940013.

Lister, S., van Nijhuis, B. (2012). The effects of alternative systems on disease and health of poultry. Pages 62–76 in Alternative Systems for Poultry: Health, Welfare and Productivity. Poultry Science Symposium Series. V. Sandilands and P. M. Hocking, ed. CABI, Wallingford, Oxfordshire, UK; Cambridge, MA.

Lopez, J., McFarlane, R., Scott, T. (2006). Environmental factors influence the prevalence of infectious bronchitis virus. Proceedings Australian Poultry Science Symposium, 18:56–59. (Abstr.)

Lovland, A., Kaldhusdal, M. (2001). Severely impaired production performance in broiler flocks with high incidence of *Clostridium perfringens*-associated hepatitis. Avian Pathology 30:73–81. DOI: http://dx.doi.org/10.1080/03079450020023230.

Lund, V., Algers, B. (2003). Research on animal health and welfare in organic farming—A literature review. Livestock Production Science, 80:55–68. DOI: http://dx.doi.org/10.1016/S0301-6226(02)00321-4.

Manning, L., Chadd, S.A., Baines, R.N. (2007). Key health and welfare indicators for broiler production. World's Poultry Science, 63:46–62.

Matthijs, M.G.R., van Eck, J.H.H., Landman, W.J.M., Stegeman, J.A. (2003). Ability of Massachusetts-type infectious bronchitis virus to increase colibacillosis susceptibility incommercial broilers: A comparison between vaccine and virulent field virus. Avian Pathology, 32:473–481. DOI: http://dx.doi.org/10.1080/03079450 31000154062.

Maxwell, M.H., Robertson, G.W. (1998). UK survey of broiler ascites and sudden death syndromes in 1993. British Poultry Science, 39:203–215. DOI: http://dx.doi.org/10.1080/00071669889132.

McDevitt, R.M., Brooker, J.D., Acamovic, T., Sparks, N.H.C. (2006). Necrotic enteritis; a continuing challenge for the poultry industry. World's Poultry Science Journal, 62:221–247. DOI: http://dx.doi.org/10.1079/Wps200593.

McIlroy, S.G., Goodall, E.A., Bruce, D.W., McCracken, R.M., McNulty, M.S. (1992). The cost benefit of vaccinating broiler flocks against subclinical infectious bursal disease on broiler production. Avian Pathology, 21:65–76.

McIlroy, S.G., Goodall, E.A., McCracken, R.M.(1989). Economic effects of subclinical infectious bursal disease on broiler production. Avian Patholiogy, 18:465–480. DOI: http://dx.doi.org/10.1080/03079458908418619.

McInerney, J.P. (1996). Old economics for new problems—Livestock disease: Presidential address. Journal of Agricultural Economics, 47:295–314.

McInerney, J.P. (2004). Animal welfare, economics and policy. Report on a study undertaken for the Farm & Animal Health Economics Division of Defra. Available at http://archive.

defra.gov.uk/evidence/economics/foodfarm/reports/documents/ animalwelfare.pdf. Accessed 25-11-2013.

McInerney, J.P., Howe, K.S., Schepers, J.A. (1992). A frame-work for the economic-analysis of disease in farm livestock. Preventive Veterinary Medicine, 13:137–154. DOI: http://dx.doi.org/10.1016/0167-5877(92)90098-Z.

Müller, H., Islam, M.R., Raue, R. (2003). Research on infectious bursal disease—The past, the present and the future. Veterinary Microbiology, 97:153–165. DOI: http://dx.doi.org/10.1016/j.vet-mic.2003.08.005.

Müller, H., Mundt, E., Eterradossi, N., Islam, M.R. (2012). Cur-rent status of vaccines against infectious bursal disease. Avian Pathology, 41:133–139. DOI: http://dx.doi.org/10.1080/03079457.2012.6 61403.

Newberry, R.C., Gardiner, E.E., Hunt, J. R. (1987). Behavior of chickens prior to death from Sudden Death Syndrome. Poultry Science, 66:1446–1450.

Olkowski, A.A., Kumor, L., Classen, H.L. (1996). Changing epidemiology of ascites in broiler chickens. Canadian Journal of Animal Science, 76:135–140.

Puister, L. (2009). Diergezondheidskosten op vleekuikenbedrijven. Available at http://edepot.wur.nl/14723. Wageningen UR, LEI. Accessed 22-11-2013.

PVE. (2011). Antibiotica aanpak pluimveesector. Beleid, cijfers, registratie en benchmarking. Available at http://www. wpsa.nl/pages/pdf/WPSA.08.12.11%20Studiedag%20Erik%20 de%20Jonge.pdf. Accessed 31-01-2013.

Rahman, M.A., Samad, M.A., Rahman, M.B., Kabir, S.M.L. (2004). Bacterio-pathological studies on salmonellosis, colibacillosis and pasteurellosis in natural and experimental infections in chickens. Bangladesh Journal of Veterinary Medicine, 2:1–8.

Reid, W.M., Johnson, J. (1970). Pathogenicity of *Eimeria acervulina* in light and heavy coccidial infections. Avian Diseases, 14:166– 171. DOI: http://dx.doi.org/10.2307/1588567.

Ruff, M.D. (1999). Important parasites in poultry production systems. Veterinary Parasitology 84:337–347. DOI: http://dx.doi.org/10.1016/ S0304-4017(99)00076-X.

Rushton, J. (2009). The Economics of Animal Health and Production. CAB International, Oxfordshire, UK.

Saif, Y.M., Fadly, A.M., Glisson, J.R., McDougald, L.R., Nolan, L.K., Swayne, D.E. (2003). Diseases of Poultry, 12th ed. Wiley-Blackwell, Ames, IA.

Sanchez, J., Stryhn, H., Flensburg, M., Ersboll, A.K., Dohoo, I. (2005). Temporal and spatial analysis of the 1999 outbreak of acute clinical infectious bursal disease in broiler flocks in Denmark. Preventive Veterinary Medicine, 71:209–223.

Scheele, C.W., van der Klis, J.D., Kwakernaak, C., Dekker, R.A., van Middelkoop, J.H., Buyse, J., Decuypere, E. (2005). Ascites and venous carbon dioxide tensions in juvenile chickens of highly selected genotypes and native strains. World's Poultry Science Journal, 61:113–129. DOI: http://dx.doi.org/10.1079/WPS200447.

Skinner, J.T., Bauer, S., Young, V., Pauling, G., Wilson, J. (2010). An economic analysis of the effect of subclinical (mild) necrotic enteritis in broiler chickens. Avian Diseases, 54:1237–1240. DOI: http://dx.doi.org/10.1637/9399-052110-Reg.1.

Steenhuisen, W., Vossen, C.M.C. (2001). Kuikens tegen coccidiose: Effectief, maar wel duurder. Pluimveehouderij, 31:10–11.

Su, G., Sorensen, P., Kestin, S. (1999). Meal feeding is more effective than early feed restriction at reducing the prevalence of leg weakness in broiler chickens. Poultry Science, 78:949–955.

Sullivan, T.W. (1994). Skeletal problems in poultry: Estimated annual cost and descriptions. Poultry Science, 73:879–882. DOI: http://dx.doi.org/10.3382/ps.0730879.

Tian, S., Baracos, V.E. (1989). Effect of Escherichia coli infection on growth and protein metabolism in broiler chicks (*Gallus domesticus*). Comparative Biochemistry and Physiology, 94a:323–331.

Van Horne, P.L.M. (2009). Productiekosten van kuikenvlees: Een internationale vergelijking. Rapport 2009–004. Wageningen UR, LEI, The Hague, the Netherlands. Available at http://edepot.wur.nl/3312. Accessed 22-11-2013.

Van Horne, P.L.M., van Harn, J., van Middelkoop J.H., Tacken, G.M.L. (2003). Perspectieven voor een alternatieve kuikenvleesketen, Marktkansen voor een langzaam groeiend vleeskuiken. Rapport 2.03.20. Landbouw-Economisch Instituut, Den Haag, the Netherlands. Available at http://edepot.wur. nl/31736. Accessed 31-01-2013.

Van Overbeke, I., Duchateau, L., Zutter, L.D., Albers, G., Ducatelle, R. (2006). A comparison survey of organic and conventional broiler chickens for infectious agents affecting health and food safety. Avian Diseases, 50:196–200. DOI: http://dx.doi.org/10.1637/7448-093005r.1.

Verma, D.S. (2007). Effects of mycotoxins on the bone structure and leg weakness in poultry: Estimation of the economic loss by leg weakness. Available at http://en.engormix.com/MA-mycotoxins/articles/effects-mycotoxins-bone-structure-t454/ p0.htm. Accessed 07-06-2013.

Vermeij, I. (2004). Primaire productiekosten biologisch kuikenvlees. Intern Rapport 505. Wageningen UR, Animal Sciences Group, Lelystad, the Netherlands. Available at http://library.wur.nl/biola/bestanden/1762980.pdf. Accessed 22-11-2013.

Vermeij, I., van Horne, P.L.M. (2008). Kostprijs biologische vleeskuikens, Rapport 170. Animal Sciences Group Wageningen University, Lelystad, the Netherlands. Available at http://www.biozoektboer.be/upload_pdf/58_1_kostprijs%20biologische%20vleeskuikens2009.pdf. Accessed 22-11-2013.

Vermeulen, A.N., Schaap, D.C., Schetters, T.P.M. (2001). Control of coccidiosis in chickens by vaccination. Veterinary Parasitology, 100:13–20. DOI: http://dx.doi.org/10.1016/S0304-4017(01)00479-4.

Verspecht, A., Vanhonacker, F., Verbeke, W., Zoons, J., van Huylenbroeck, G. (2011). Economic effect of decreasing stocking densities in broiler production in Belgium. Poultry Science, 90:1844–1851. DOI: http://dx.doi.org/10.3382/ps.2010-01277.

Voeten, A.C. (2000). Gezond Pluimvee, Handboek voor de beroepspluimveehouder en sportfokker. 3rd ed. Utigeverij Terra, Warnsveld.

Voeten, A.C., Braunius, W.W., Orthel, F.W., van Rijen M.A.J. (1988). Influence of coccidiosis on growth rate and feed conversion in broilers after experimental infections with *Eimeria acervulina* and *Eimeria maxima*. Veterinary Quarterly, 10:256–264. DOI: http:// dx.doi.org/10.1080/01652176.1988.9694182.

Weeks, C.A., Danbury, T.D., Davies, H.C., Hunt, P., Kestin, S.C. (2000). The behaviour of broiler chickens and its modification by lameness. Applied Animal Behaviour Science, 67:111–125. DOI: http://dx.doi.org/10.1016/S0168-1591(99)00102-1.

Wheelhouse, R.K., Groves, B.I., Hammant, C.A., van Dijk, C., Radu, J. (1985). Effects of Coccidiostats and dietary protein on performance and water consumption in broiler chickens. Poultry Science, 64:979–985. DOI: http://dx.doi.org/10.3382/ps.0640979.

Williams, R.B. (1998). Epidemiological aspects of the use of live anticoccidial vaccines for chickens. International Journal for Parasitology, 28:1089–1098.

Williams, R.B. (1999). A compartmentalized model for the estimation of the cost of coccidiosis to the world's chicken production industry. International Journal for Parasitology, 29:1209–1229.

Williams, R.B., Bushell, A.C., Répérant, J.M., Doy, T.G., Morgan, J. H., Shirley, M.W., Yvoré, P., Carr, M.M., Frémont, Y. (1996). A survey of *Eimeria* species in commercially-reared chickens in France during 1994. Avian Pathology, 25:113–130. DOI: http:// dx.doi.org/10.1080/03079459608419125.

Yalçin, S., Settar, P., Dicle, O. (1998). Influence of dietary protein and sex on walking ability and bone parameters of broilers. British Poultry Science, 39:251–256. DOI: http://dx.doi.org/10.1080/00071669889213.

Yohannes, T., Sharma, A.K., Sumi, V., Rout, S.S. (2012). Clinical manifestation and growth performance of broiler chickens fed with T-2 toxin and co-infected with infectious bronchitis virus. ISABB Journal of Food and Agricultural Sciences, 2:30–35.

Chapter 7

Economic feasibility of animal welfare improvements in Dutch intensive livestock production: A comparison between broiler, laying hen, and fattening pig farms

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Abstract

This study compared the economic feasibility of production systems with different levels of animal welfare (AW) in the broiler, laying hen, and fattening pig sectors. Economic feasibility over a five-year time horizon was assessed using stochastic bio-economic simulation models. The results suggest that the main determinant of economic feasibility in each sector is the producer price. It is not only the level of the price premium but also the certainty and variability of this premium that is important in the decision to convert to an alternative system. From the perspective of the farm, different approaches should be followed in the three sectors to further develop the market for products with higher levels of AW. The results imply that the broiler sector has the best perspective in the short to medium term for developing this market. In the fattening pig sector, conversion options should be made more financially attractive, for example by increasing price premiums or providing conversion subsidies. The laying hen sector has the worst prospects for improving AW in the short to medium term. Therefore, given the current production systems in this sector, producer price premiums need to be increased in order to increase the adoption of alternative production systems.

Keywords: Farmers' decision-making, Animal welfare, Barriers to adoption, Broiler production, pig production

Introduction

Increasing public concern in recent decades about animal welfare (AW) in livestock production has led to higher legal requirements in many European countries and in the European Union (Immink et al., 2013; Vanhonacker and Verbeke, 2014). In the Netherlands, several market initiatives were introduced, which set AW standards higher than the minimum legal requirements (Veissier et al., 2008; Oosterkamp et al., 2011). In this regard, three market segments can be distinguished along the AW spectrum: conventional, which complies with minimum legal standards, a middle-market segment, which supplies products that go beyond conventional standards but do not meet organic standards, and a top-market segment, which supplies organic products or products with similar AW standards.

Farmers voluntarily choose to supply products, which have higher AW standards than the legal minimum requirements. A farmer's decision to convert to a production system with higher AW standards predominantly depends on financial factors, i.e., on the farmer's perception of the economic viability of the production system, in terms of the level of the income they earn from the farm and business risks, such as certainty of income (Hardaker et al., 2004; Gocsik et al., 2014). In this regard, the degree of reversibility of the changes to the production system is relevant, as it influences the riskiness of the investment (Dixit and Pindyck, 1994; Gocsik et al., 2014). The middle-market and top-market segments have different characteristics in terms of reversibility. Conversion to a middle-market system predominantly involves changes that are reversible in the short to medium term and that primarily affect variable costs. Farmers, thus, can easily revert to the previous production system or practice without considerable costs. Conversion to a top-market system, however, usually requires a farmer to make irreversible changes to the farm that affect fixed costs, and which therefore obligate farmers for the depreciation period of 10 to 25 years, depending on the particular investment (Pindyck, 1991). Furthermore, irreversible investments eventually become sunk costs and, as such, increase the financial risk to farmers.

Intensive livestock production sectors in the Netherlands, such as the poultry and fattening pig sectors, share some similar features. First, these sectors have a similar cost structure; variable costs represent roughly two-thirds of the total production costs. The main drivers of variable costs are feed costs and the cost of purchasing livestock. Second, these sectors are characterized by a large number of animals kept on the farm and small margins per production unit. Third, AW concerns are particularly important in livestock sectors that are highly industrialized and that pursue intensive animal production, such as broiler chicken, egg, and fattening pig production (Bennett, 1996, 1997; Moynagh, 2000). Hence, in recent years, these three sectors have developed similar market concepts with higher AW standards than the minimum legal requirements (Baltussen et al., 2010; Hoste, 2010; van Horne, 2012; Gocsik et al., 2013). The similarities in the production characteristics of intensive livestock sectors suggest that the future development of new concepts and production systems aimed at improving AW can be pursued in a similar way for these three sectors. Whether this is actually the case is currently unknown. It is possible that differences exist between these three sectors in terms of the on-farm consequences of alternative production systems with higher AW standards. These differences would then suggest the need for different approaches to increase the uptake of these systems by farmers.

In the light of the foregoing, the aim of this study is to compare the economic feasibility of alternative production systems with higher levels of AW for broiler, laying hen and fattening pig farms. The paper also analyses the riskiness of implementing different production systems, with particular regard to the degree of reversibility of the investment.

Materials and methods

Approach

The analysis of the economic feasibility of alternative production systems consisted of four distinct steps. First, an inventory of the various production systems in each livestock sector, which represent a farmer's choice set, was made. Second, the specifics of the farmer's choice problem were defined. Third, stochastic bio-economic simulation models were developed for each sector to calculate the economic feasibility of different production systems. Fourth, a measure of economic feasibility was defined and used to compare production systems within and between sectors. Last, sensitivity analysis was conducted for the stochastic input variables affecting economic feasibility. In the following sections, these steps are described in detail.

Recent developments and production systems in intensive livestock production sectors in the Netherlands

In recent decades, developments in broiler production have been concentrated in the following areas: type of breed used in a production system, enrichment, stocking density, provision of outdoor access, lighting regime, flock size, and barn size (Gocsik et al., 2013). The standards for the conventional broiler production system are based on EU guidelines (EC, 2007a, 2007b, 2008a) and resemble the industrial type of production in many European countries (Roex and Miele, 2005). In addition to the conventional system, five alternative production systems were included in the analysis. Three of these five systems, Gildehoen, Volwaard, and Puur en Eerlijk, are considered as the middle-market segment. The other two systems, Kemper-Mais Scharrelkip and organic, are considered as the top-market segment. These six systems are currently the most prevalent systems in the Netherlands (Ellen et al., 2012). The requirements of the six selected systems are shown in Table 7.1 (Gocsik et al., 2013). The Gildehoen system requires improvements compared to the conventional system in the following areas: the type of breed, stocking density, provision of enrichment, and lighting regime. The Volwaard and Puur en Eerlijk systems are comparable to each other. They both require the use of a slow-growing breed, a growth period of a minimum of 56 days, provision of enrichment, and a covered veranda. The two main differences between the two systems are that the Puur en Eerlijk system requires a lower stocking density compared to the Volwaard system, and an uninterrupted dark period of eight hours instead of six hours. Chickens kept according to the standards of the Kemper-Mais Scharrelkip system live for at least 63 days, are provided with enrichment, an outdoor access of 1 m^2 per chicken, and with a maximum of eight hours of dark period per day. In the Kemper-Mais Scharrelkip system, the flock size is limited to 5,000 animals. The organic system complies with the EU standards for organic production.

For the laying hen sector, the EU defines four housing systems with regard to product certification: enriched cages, barn systems, free-range systems, and organic systems (EC, 1999). Egg production in battery cages was banned by the EU from 2012 onwards. Retailers in the Netherlands had already stopped selling eggs from battery cages since 2006, due to pressure from animal rights organizations. Enriched cage systems as an alternative for battery cages were not publicly or politically accepted in the Netherlands, therefore loose-housing systems became the predominant systems for egg production (Dekker et al., 2011). Therefore, prior to the introduction of the ban in 2012, the majority of farmers in the Netherlands had already converted from cage systems to the more animal-friendly loose-housing systems. Loose-housing systems, i.e., aviary systems (single-tiered or multi-tiered), free-range systems, and organic systems, account for 82% of the total egg production in the Netherlands (PVE, 2013). Cage systems (enriched cages and colony systems) were excluded from the analysis, as the contribution of these systems to the total egg production is relatively small, i.e., 18% (PVE, 2013). Similar to broiler production, a middle-market and top-market segment have been developed with a diversity of production systems and market concepts Table 7.2 presents the requirements of the four production systems included in the analysis. Multi-tiered aviary is considered as the conventional system in this study, as it is the most prevalent egg production system in the Netherlands. One alternative system, the multi-tiered aviary with covered

Table 7.1 Requirements of selected broiler production systems in the Netherlands (Gocsik et al., 2013)

	Conventional	Middle-market segment			Top-market segment	
Variable	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Type of chicken	Fast-growing	Slow-growing	Slow-growing	Slow-growing	-	Slow-growing
Length growth period (day)	-	49	56	56	63	>70
Weight at delivery (g)	2,200	2,150	2,300	2,300	-	-
Enrichment						>95% organic feed
Provision of grain	-	Twice a day	Optional	2 g/day from 2nd week	2 g/day from 3rd week	-
% grain in feed	-	> 70% sustainable soy	Ca. 70%	> 70%	> 70%	-
Provision of straw	-	Yes	Yes	Yes	1 straw bale/ 1,000 animals	-
Stocking density						
kg/m^2	39 (42)	31	31[1]	25[1]	27.5	21
Chickens/m^2		15		12	13[2]	10
Outdoor access	No	No	Covered veranda	Covered veranda	Outdoor 1m^2/chicken	Outdoor 4m^2/chicken
Lighting regime						
Daylight	No	Yes	No	Yes	10 lux by 1,200 lux outside	Yes
Dark period (hours/day)	6h/24h, of which 4h uninterrupted	6h	6h	8h	Max. 8h	>8h
Flock size	-	-	-	-	Max. 5000 animals	Max. 4800 animals
Barn size	-	-	-	-	-	Max. 1600 m^2

'-' No requirement.

[1] Included covered veranda.

[2] Fifteen chickens/m^2 in the first 3 weeks.

Table 7.2 Requirements of selected laying hen production systems in the Netherlands

	Conventional	Middle-market segment	Top-market segment	
Variable	Multi-tiered aviary	Multi-tiered aviary with covered veranda	Multi-tiered aviary with covered veranda and outdoor access	Organic – multi-tiered
Space requirement (hen/m^2)	18	18	18	12
Daylight in the barn	-	Yes	Yes	Yes
Enrichment	-	-	-	Provision of grain and straw
Outdoor access	-	Covered veranda[1]	Covered veranda[2] + Outdoor access	Covered veranda[2] + Outdoor access
Beak trimming	Yes	Yes	Yes	No

'-' No requirement.

[1] Min. 20% of the total surface of the barn.

[2] Min. 50% of the total surface of the barn.

Table 7.3 Requirements of selected fattening pig production systems in the Netherlands

	Conventional	Middle-market segment			Top-market segment	
Variable	Conventional	Better Life 1* - small groups	Better Life 1* - large groups	Canadian bedding	Free-range	Organic
Indoor space (m^2/110 kg fattening pig)	0.8	1.0	0.9	1.0	0.7	1.3
Outdoor space (m^2/110 kg fattening pig)	-	-	-	-	0.7	1.0
Solid floor (%)	40	40	40	90	100	50
Bedding	Concrete, litter	Concrete, litter	Concrete, litter	Concrete, sawdust	Concrete, straw	Concrete, straw
Group size (pigs per group)	8-20	8-20	>40	20-35	8-30	8-30
Daylight in the stable	-	-	-	Yes	Yes	Yes
Enrichment	Metal chain with ball	Wood, sturdy rope, straw, and special scrub	Wood, sturdy rope, straw, and special scrub	Sawdust, and special scrub	Straw, roughage, and special scrub	Straw, roughage, and special scrub
Castration	Yes	No	No	No	Yes	Yes
Tail docking	Yes	Yes	Yes	No	No	No

'-' No requirement.

veranda, is considered as the middle-market segment. Two systems, the multi-tiered aviary with covered veranda and outdoor access and the organic system, are considered as the top-market segment (van Horne, 2012). In this study, calculations were made for multi-tiered systems, however production is also feasible in single-tiered aviaries For the fattening pig sector, the Dutch legal requirements that define the conventional production system are higher than the minimum EU legal requirements. The EU prescribes a minimum living surface of 0.65 m^2 per 110 kg of fattening pig for conventional systems, whereas the Dutch legislation prescribes 0.80 m^2 per 110 kg of fattening pig (EC, 2008b; Roex and Miele, 2005) (Table 7.3). Further, while the EU regulations allow pigs to be kept on a fully-slatted floor, the Dutch requirements specify a solid floor of at least 40% of the total surface area. The alternative systems set higher requirements compared to conventional standards in the following areas: space requirement, provision of free-range, percentage of solid floor, bedding, group size, daylight, enrichment, and mutilations (i.e., castration and tail docking). The middle-market segment comprises of three systems, the Better Life 1* system with either small or large groups and the Canadian bedding system. The Better Life 1* system allows farmers to keep pigs in either small (8 to 20 pigs per group) or large groups (more than 40 pigs per group). In the case of small groups, the minimum living space required is 1 m^2 per 110 kg fattening pig, while for larger groups this is 0.9 m^2. In either system, castration is not allowed and pigs should be provided with natural enrichment (e.g., wood and sturdy rope) and special scrub facilities. In the Canadian bedding system, pigs are kept on sawdust bedding of 5 to 10 cm on a solid floor, which covers 90% of the total surface area. There is daylight in the pig stables. A group size of 20 to 35 pigs is required, and sawdust as enrichment and special scrub facilities need to be provided. Castration and tail docking are not allowed. The free-range and organic systems, considered as the top-market segment, are similar in many aspects. Similarities include: a group size of 8 to 30 pigs, castration allowed, tail docking prohibited, pigs kept in daylight, straw and roughage provided for enrichment, and provision of special scrub facilities. However, organic systems require a larger indoor and outdoor space, while free-range systems require a 100% concrete solid floor compared to 50% for organic systems.

Choice problem: Transition from conventional to alternative systems

This study investigated the farmer's choice problem of converting from a conventional system to an alternative production system with improved AW. First, the default farm situation was defined for the conventional system in each sector. The conventional farm was assumed to have been built 15 years ago and was financed by 70% debt and 30% equity capital. Loan payments were calculated assuming an annuity loan over a 20-year period, with 0% down payment and an interest rate of 3.55%. The debt-to-equity ratio in the beginning of the 16th year was 60/40. As the economic life span of farm buildings was 25 years, 10 years remained to fully depreciate the buildings. However, the economic lifespan of farm inventory is 12.5 years, hence by the 16th year the inventory was fully depreciated. It is assumed that in the 16th year the current inventory has to be replaced. When switching to another system, it was assumed that no additional barn area would be built, however the farm could be expanded with covered veranda or outdoor access. Regarding the size of the conventional farm, it was assumed that one full-time labor equivalent (FTE) was available to work in the farm, which implies a broiler farm with 90,000 animal places in three barns, a laying hen farm with 40,000 animal places, and a fattening pig farm with 4,200 animal places. In addition, when switching to an alternative system, the labor requirement of the farm was assumed not to exceed one FTE. Two of the broiler production systems, Kemper-Mais Scharrelkip and organic, introduce limits on flock and farm size. The maximum number of chickens that can be kept in a barn is restricted to 5,000 in the Kemper-Mais Scharrelkip system and to 4,800 in the organic system. Because it was assumed that the existing farm had three barns, 15,000 chickens could be kept on the farm when switching to the Kemper-Mais Scharrelkip system and 14,400 chickens when switching to the organic system. New investments were financed by equity if the investment amount did not exceed €15,000. Investments exceeding €15,000 were financed by an annuity loan with a 0% down payment and 3.55% interest. For investments between €15,000 and €50,000, the term of the loan was five years. For investments between €50,000 and €150,000, the term of the loan was 10 years. Investments larger than €150,000 were financed with a 20-year loan.

Stochastic bio-economic simulation model

Stochastic bio-economic simulation models were used to assess the economic feasibility of the different livestock production systems. Calculations for broiler production were made using the model described in Gocsik et al. (2013). Similar models were developed for laying hen and fattening pig production. The economic feasibility of different production systems was simulated over a five-year time horizon. Simulations were conducted using @Risk in MS Excel (Microsoft Corporation, Redmond, WA).

Technical inputs

Production uncertainty was incorporated in the simulation models by defining probability distributions for the key technical variables. For broiler production, four variables were defined as stochastic: weight at delivery, daily growth, feed conversion ratio, and mortality (Gocsik et al., 2013). For details on the technical inputs for broiler production, please refer to Gocsik et al. (2013). Data for the technical variables for the models for laying hen and fattening pig production were gathered from scientific literature and technical reports. Where information was not available from literature, estimations were made based on expert opinion. For laying hen production, the laying percentage and feed intake were defined as stochastic variables. The laying percentage determines the number of eggs produced, which is a main driver of the returns; while feed intake determines feed cost (Mollenhorst et al., 2006). In pig production, the stochastic variables included in the model were: mortality, daily growth, and feed conversion ratio. Data on the variation in these technical variables were only available for the conventional system; no data was available for the alternative systems for laying hen and fattening pig production. Therefore, variation in technical performance was estimated for the alternative systems following the methodology described in Gocsik et al. (2013). The relative variation of each variable (measured by the coefficient of variation, i.e., CV; SD/mean) was estimated based on data from conventional production. To estimate the absolute deviations of the variables in the alternative systems, the same relative variations were assumed as in the conventional system.

To reflect the interrelations between technical variables, correlations between certain technical variables were included in the model, provided that data were available to estimate correlation coefficients. These data were only available for conventional pig production (Agrovision, 2012). Correlations between mortality, daily growth, and feed conversion were estimated from data for the period 2008 to 2102. As data were not available for alternative pig production systems, the same correlations between variables were assumed for the alternative pig production systems. Correlation between mortality and daily growth was estimated at -0.577 *(P = 0.003)*, that between mortality and the feed conversion ratio was 0.239 *(P = 0.250)*, and the correlation between daily growth and the feed conversion ratio was -0.383 *(P = 0.059)*. The main technical variables are presented in the Appendix 7 (Table 7A.1, Table 7A.2, and Table 7A.3).

Prices

Farm income is determined by returns and costs. Returns are predominantly driven by the producer price. In both laying hen and fattening pig production, the main cost items are feed costs and purchase of livestock (Den Ouden, 1996; Mollenhorst et al., 2006). These prices are characterized by high volatility, therefore it is important to account for this volatility. Producer prices (egg price in laying hen production and pork meat price in fattening pig production), feed prices, and the price of livestock (pullet price and piglet price) were simulated over the five-year planning horizon using a geometric random walk (GRW) model, following the methodology applied in the broiler simulation model in Gocsik et al. (2013). For the simulation of future prices, the closed-form expression for price P_t was applied (Fabozzi and Markowitz, 2011):

$$P_t = P_0 \cdot e^{\left(\mu - \frac{1}{2}\sigma^2\right) \cdot t + \sigma\sqrt{t} \cdot \varepsilon_t}, \qquad \mathbf{7.1}$$

where P_t is the price at time t, P_0 is the initial price, ε_t is an independent and identically distributed standard normal random variable – in other words, $\varepsilon_t \sim$ IID N(0,1) – and μ and σ are constant. The price in the next time period is a multiple of a random term and the price from the previous period.

Interdependency between prices was incorporated by using correlated random walks instead of independent random walks. The correlated GRW model implies that log returns are jointly normally distributed. That is, the error terms were correlated random variables with zero means and a given covariance structure, estimated based on the correlation between log returns. Correlations were calculated between

$$\ln\left(\frac{P_{t+i}^{(1)}}{P_t^{(1)}}\right) \text{ and } \ln\left(\frac{P_{t+i}^{(2)}}{P_t^{(2)}}\right) \text{ and } \ln\left(\frac{P_{t+i}^{(3)}}{P_t^{(3)}}\right), \qquad \mathbf{7.2}$$

where superscripts (1), (2), and (3) correspond to producer price, feed price, and price of livestock, respectively. Table 7.4 presents the Spearman's rank correlation coefficients for each sector. Data were only available for conventional production in all three sectors, therefore the same correlation coefficients were assumed for alternative systems.

To simulate future prices, the parameters μ and σ were estimated for the model. Given a historical series of prices, the parameters were estimated in three steps (Fabozzi and Markowitz, 2011):

1. Compute $\ln\left(\frac{P_{t+i}}{P_t}\right)$ for each time period t, t=0, ..., T-1.
2. Estimate the volatility of the GRW, σ, as the SD of all $\ln\left(\frac{P_{t+i}}{P_t}\right)$.
3. Estimate the drift of the GRW, μ, as the average of all $\ln\left(\frac{P_{t+i}}{P_t}\right)$, plus one-half of the SD.

Table 7.4 Spearman's rank correlation coefficients for the three sectors, with *P*-values in parentheses

	Broiler production			Laying hen production			Fattening pig production		
Variable	Producer price	Feed price	Day-old chick price	Producer price	Feed price	Pullet price	Producer price	Feed price	Piglet price
Broiler production[1]									
Producer price	1	0.443 (*P* = 0.034)	0.286 (*P* = 0.493)						
Feed price		1	0.381 (*P* = 0.352)						
Day-old chick price			1						
Laying hen production[2]									
Producer price				1	0.135 (*P* = 0.569)	0.314 (*P* = 0.544)			
Feed price					1	0.600 (*P* = 0.208)			
Pullet price						1			
Fattening pig production[3]									
Producer price							1	0.793 (*P* = 0.000)	0.079 (*P* = 0.781)
Feed price								1	0.586 (*P* = 0.022)
Piglet price									1

[1] Gocsik et al., 2013

Continued

Table 7.4 (Continued) Spearman's rank correlation coefficients for the three sectors, with P-values in parentheses

[2] Different time periods were available for the producer, feed, and pullet prices to estimate correlation coefficients. For the producer price (referring to the price of cage eggs) and feed price, annual price data from 1993-2012 were available; for the pullet price, annual data from 2007-2012 were available (KWIN-V, 2011, 2012; LegManager Agrovision, 2013; LEI, 2013).

[3] Correlation coefficients were calculated based on annual price data from 2008-2012 (Agrovision, 2012).

The estimated parameters for broiler production systems are presented in Table 7.5.

Table 7.5 Estimated parameters for stochastic price simulation in broiler production systems (Gocsik et al., 2013)

	Conventional	Middle-market segment		Top-market segment	
Variable[1]	Conventional	Gildehoen	Volwaard, Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Producer price - meat					
P_0 (€/kg)	0.794	0.944	1.040	1.310	2.112
σ	0.123	0.123	0.123	0.123	0.123
Feed price					
P_0 (€/100kg)	31.839	30.883	30.883	30.883	45.211
σ	0.085	0.085	0.085	0.085	0.085
Day-old chick price					
P_0 (€/piece)	0.302	0.320	0.320	0.320	0.438
σ	0.036	0.036	0.036	0.036	0.036

[1] P_0 = initial price, σ = SD of logarithmic returns

For details on the methodology used to estimate prices in broiler production, please refer to Gocsik et al. (2013). Parameters for the laying hen and pig production systems were estimated similarly, however using other data sources. The estimated parameters for these two sectors and the main data sources used are presented in Table 7.6 for the laying hen production systems and in Table 7.7 for the pig production systems.

Variable and fixed costs

Data on variable and fixed costs were gathered from scientific literature and technical reports (see Appendix 7). No data were available in the literature for some of the relatively newer production systems, which have only recently been introduced. In these cases, expert opinion was used. Variable costs that are likely to be correlated with technical performance (for example, mortality and health care costs) should, in principle, be modelled as stochastic variables. However, because these variable costs represent a relatively small proportion of the total variable cost, these variable costs were included as deterministic variables (Gocsik et al., 2013). Variable costs are presented in Tables 7A.4, 7A.5, and 7A.6 in the Appendix 7, and fixed costs (replacement costs of buildings, equipment, and free-range areas) are presented in Tables 7A.7, 7A.8, and 7A.9 in the Appendix 7. Replacement costs of buildings were the same for all the systems in each sector, because it was assumed that the current buildings would remain in use in the farm after the transition to a new system was made. However, replacement costs of inventory differed per system. Depreciation was 4% on buildings, 8% on equipment, and 10%

on the air scrubber. Calculated interest was 2.5% on land, 5% on average invested capital in buildings and equipment, and 6% on average invested capital in livestock. Organic systems can benefit from an interest rate that is lower than for conventional systems (termed ‘green interest’). Therefore, a 4% interest rate was assumed on the average invested capital in new equipment for this system (Vermeij and van Horne, 2008).

Table 7.6 Estimated parameters for stochastic price simulation in laying hen production systems

	Conventional	Middle-market segment	Top-market segment	
Variable[1]	Multi-tiered aviary	Multi-tiered aviary with covered veranda	Multi-tiered aviary with covered veranda and outdoor access	Organic – multi-tiered
Producer price - egg				
P_0 (€/kg)	0.94[2]	0.99[3]	1.04[4]	2.00[5]
σ	0.19[6]	0.19[7]	0.19[7]	0.19[7]
Feed price				
P_0 (€/100kg)	19.50[8]	19.50[8]	19.50[8]	37.00[8]
σ	0.11[9]	0.11[9]	0.11[9]	0.11[10]
Pullet price				
P_0 (€/piece)	3.70[11]	3.76[12]	3.76[12]	6.20[13]
σ	0.05[14]	0.05[15]	0.05[15]	0.05[15]

[1] P_0 = initial price, σ = SD of logarithmic returns.

[2] Average price based on the period 2007-2010 (LEI, 2013).

[3] +0.05 €/kg compared to the price of eggs from the conventional multi-tiered aviary (KWIN-V, 2011).

[4] +0.10 €/kg compared to the price of eggs from the conventional multi-tiered aviary (KWIN-V, 2011).

[5] +92% compared to price of free-range eggs (KWIN-V, 2011).

[6] Estimation based on annual price data from 2006-2011 (LEI, 2013).

[7] Same volatility is assumed as in the multi-tiered aviary system.

[8] KWIN-V (2011)

[9] Estimation based on the period 1992-2012 (LEI, 2013).

[10] Same volatility is assumed as in non-organic systems.

[11] Average price from 2007-2010 (LegManager_Agrovision, 2013).

[12] +1.5% compared to conventional multi-tiered aviary systems, estimation based on the price difference between the price of pullets in conventional multi-tiered aviary systems and that in free-range in 2012 (KWIN-V, 2011).

[13] +65% compared to free-range, estimation based on the price difference between the price of pullets in free-range systems and that in organic in 2012 (KWIN-V, 2011).

[14] Estimation based on the period 2007-2012 (LEI, 2013).

[15] Same volatility is assumed as in the multi-tiered aviary system.

Table 7.7 Estimated parameters for stochastic price simulation in fattening pig production systems

	Conventional	Middle-market segment			Top-market segment	
Variable[1]	Conventional	Better Life 1*- small groups	Better Life 1* - large groups	Canadian Bedding	Free Range	Organic
Producer price - meat						
P_0 €/kg carcass	1.27[2]	1.35[3]	1.35[3]	1.35[4]	1.51[5]	2.54[6]
σ	0.12[7]	0.12[8]	0.12[8]	0.12[8]	0.12[8]	0.06[9]
Piglet price						
P_0 €/# (25 kg)	34.40[2]	35.40[10]	35.40[10]	35.40[10]	41.50[11]	86.00[6]
σ	0.19[7]	0.19[8]	0.19[8]	0.19[8]	0.19[8]	0.26[9]
Feed price						
P_0 €/100 kg	22.90[2]	22.90[2]	22.90[2]	22.90[2]	22.90[2]	36.70[12]
σ	0.13[7]	0.13[8]	0.13[8]	0.13[8]	0.13[8]	0.26[9]

[1] P_0 = initial price, σ = SD of logarithmic returns.

[2] Average price 2007-2011 (LEI, 2013).

[3] 7% price premium compared to conventional products (Spreeuwenberg, 2013; Quinten, 2013).

[4] 7% price premium compared to conventional products (Krekels, 2013).

[5] 19% price premium compared to conventional products (Boerderij, 2013).

[6] 100% price premium compared to conventional products (Gerbers, 2013).

[7] Estimation based on the period 1993-2011, excluding the years 1997-1999 to eliminate the effects of the Swine Fever epidemic in the Netherlands during this period (LEI, 2013).

[8] Same volatility assumed as in the conventional system.

[9] Gerbers, 2013

[10] Spreeuwenberg, 2013 and Quinten, 2013

[11] Boerderij, 2013

[12] Hoste, 2010

Interest rates and income tax

The annual short-term and long-term loan interest rates were assumed fixed over the time horizon in this study. Interest rates of 2.35% and 3.55% were assumed for short-term and long-term loans, respectively (Gocsik et al., 2013). As previously stated, organic producers can benefit from a lower interest rate to finance long-term investments. For organic farms, a 1% lower rate interest rate was assumed for long-term loans. Income tax was calculated following the method of Gocsik et al. (2013).

Measure of economic feasibility under risk

In this study, economic feasibility was defined as in Gocsik et al. (2013). If time to failure, T_F, is a random variable with a cumulative probability distribution, F_{TF}, then economic feasibility, E, for the period (0, T) is defined as

$$E(T) = 1 - F_{TF}(T). \quad \textbf{7.3}$$

System failure was defined in terms of the capital debt repayment margin (CDRM) which measures the amount of money that remains after all the operating expenses have been paid. Capital debt repayment margin is calculated as net farm income plus depreciation plus nonfarm income minus family withdrawals minus tax expenses minus scheduled principal payments (Barry and Ellinger, 2012). A negative cumulative CDRM at the end of the fifth year (CDRM-5) indicates system failure, i.e., the farm is not able to fulfil all of its financial obligation. Economic feasibility is estimated by the simulated relative frequency of surviving realizations:

$$\hat{E}(T) = \frac{n(T)}{N}, \quad \textbf{7.4}$$

where n(T) is the number of non-failures at time T, and N is the total number of iterations used in the simulation. In this study, each scenario was repeated 5,000 times using Latin Hypercube sampling in the @Risk software environment (Palisade Corporation, Ithaca, New York).

Sensitivity analysis

To assess the key determinants of the CDRM, a sensitivity analysis was conducted for the stochastic input variables affecting the CDRM. For this purpose, the multivariate stepwise regression analysis available in the @Risk software was used. The multivariate stepwise regression analysis calculates β coefficients for each stochastic input variable, which measure the sensitivity of the output to the distribution of each stochastic input variable.

Results

Table 7.8 presents the CDRM at the end of the first year (CDRM-1) after the conversion to a production system and the cumulative measure of economic feasibility at the end of the fifth year (CDRM-5).

Table 7.8 Economic feasibility of various production systems per sector in the short term (CDRM-1) and medium term (CDRM-5): average, standard deviation (SD), and coefficient of variation (CV) for each measure

	Capital debt repayment margin at the end of the 1st year (CDRM-1)			Cumulative capital debt repayment margin at the end of the 5th year (CDRM-5)		
	Average	SD	CV	Average	SD	CV
Broiler production systems						
Conventional	-45,306	100,375	2.22	-230,183	352,392	1.53
Gildehoen	-11,895	66,708	5.61	-68,993	221,087	3.20
Volwaard/	22,258	58,967	2.62	74,212	194,098	2.62
Puur en Eerlijk	2,564	52,829	20.60	-12,149	165,852	13.65
Kemper-Mais Scharrelkip	-123	16,748	136.16	-51,307	58,595	1.14
Organic	-16,935	29,041	1.71	-77,557	84,464	1.09
Laying hen production systems						
Multi-tiered aviary	-6,773	94,240	13.91	-42,353	646,538	15.27
Multi-tiered aviary with covered veranda	-23,857	89,757	3.76	-103,163	574,103	5.57
Multi-tiered aviary with free-range	-79,859	88,963	1.11	-379,510	511,093	1.35
Organic – multi-tiered	-52,578	66,814	1.27	-183,718	402,952	2.19
Fattening pig production systems						
Conventional	-22,146	117,002	5.28	-295,318	321,510	1.09
Better Life 1*- small groups	6,033	92,053	15.26	-266,517	315,175	1.18
Better Life 1*- large groups	-8,095	102,351	12.64	-280,219	322,595	1.15
Canadian bedding	-42,953	96,508	2.25	-333,102	322,826	0.97
Free-range	-61,880	77,271	1.25	-315,799	320,132	1.01
Organic	-84,360	165,763	1.96	-366,010	349,925	0.96

With regard to broiler production systems, the conventional system had the lowest CDRM-1 and CDRM-5, implying that this system was, on average, the least economically feasible system in the short to medium term. However the relative variation of the measures, as measured by the coefficient of variation (CV), was generally higher for the alternative systems. Exceptions were the organic system, which showed lower relative variation than the conventional system in both CDRM-1 and CDRM-5, and the Kemper-Mais Scharrelkip system, which showed a lower relative variation in CDRM-5 compared to the conventional system. An explanation for this result is that these systems were modelled as small-scale systems. Regarding laying hen production, it is striking that all the alternative systems had lower CDRM-1and CDRM-5 compared to the multi-tiered aviary system, which is considered the conventional system in this study. At the same time, the alternative laying hen systems had a lower relative variation in CDRM-1 and CDRM-5 compared to the conventional system. As for fattening pig production, all the systems had negative CDRM-5. Both Better Life 1* with small groups and Better Life 1* with large groups had a higher CDRM-5 than the conventional system. The CDRM-5 of the other systems was lower compared to that of the conventional. The relative variation of CDRM-5 was similar for all fattening pig systems.

A graphical representation of the economic feasibility for each sector in the medium term is shown in Figure 7.1, Figure 7.2, and Figure 7.3. The figures show the cumulative distribution functions (CDFs) of the CDRM-5 for each livestock production sector. Because the vertical axis represents the probability, all values ranged from 0% to 100%. The horizontal axis depicts the values for CDRM-5. The CDF gives the probability of having a CDRM-5 less than or equal to a given value on the x-axis. According to our definition, a system is economically feasible if the CDRM-5 is greater than or equal to zero. In the case of the broiler production systems, the probability of the middle-market segment systems being economically feasible was 39% for Gildehoen, 67% for Volwaard, and 49% for Puur en Eerlijk, compared to 27% for the conventional system (Figure 7.1). In other words, Gildehoen, Volwaard, and Puur en Eerlijk had a higher economic feasibility and a lower absolute variation (steeper curves) than the conventional system. The systems in the top-market segment, Kemper-Mais Scharrelkip and organic, had a lower economic feasibility than the conventional system, with probabilities of being economically feasible of 19% and 18%, respectively. The steeper curves of the Kemper-Mais Scharrelkip and organic systems indicate less variation in economic feasibility compared to the conventional and other alternative systems, which can be explained by the fact that these are small-scale systems.

With regard to the laying hen production systems, Figure 7.2 shows that the multi-tiered aviary system, considered the conventional system in this study, had the highest probability (44%) of being economically feasible. The probability of being economically feasible for the aviary system with covered veranda, which represents the middle-market segment, was similar (i.e., 40%) to the conventional system. The two top-market segment systems, the free-range and organic system, performed worse than the conventional system, with a probability of being economic feasible of 22% for the free-range system and 29% for the organic system. The

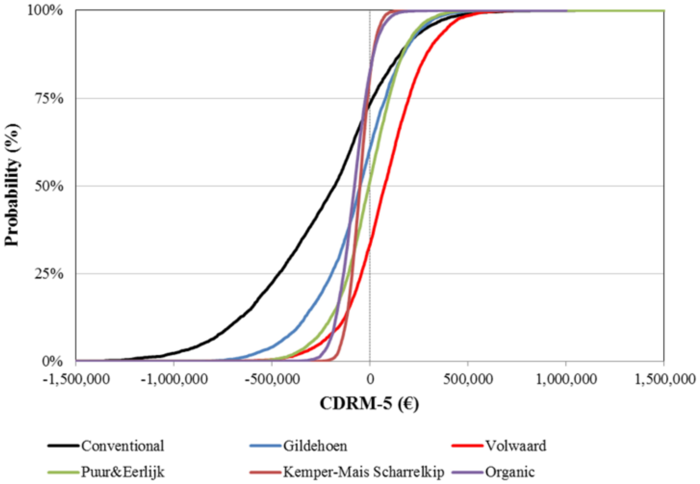

Figure 7.1 Cumulative distribution function (CDF) of the cumulative debt repayment margin at the end of the 5th year (CDRM-5) for broiler production systems

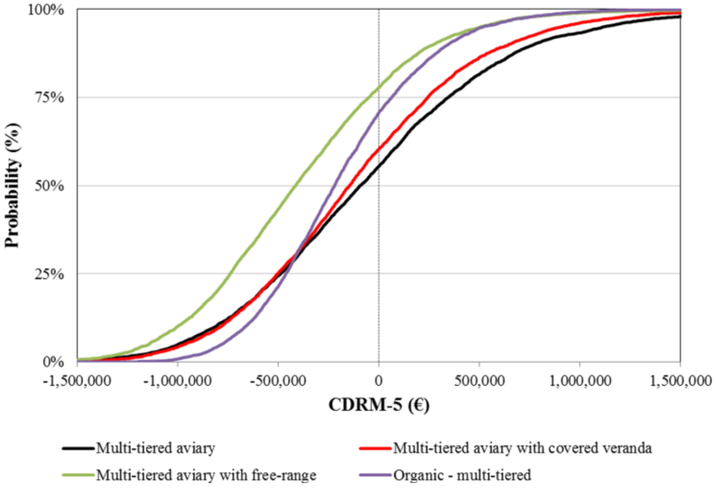

Figure 7.2 Cumulative distribution function (CDF) of the cumulative debt repayment margin at the end of the 5th year (CDRM-5) for laying hen production systems

slightly lower variation in economic feasibility for the organic system, indicated by the steeper curve, resulted from the smaller production scale.

Figure 7.3 shows the economic feasibility of the fattening pig production systems. The CDF curves are almost similar, which suggests that there were only slight differences in the economic feasibility of different systems. The probability of being economically feasible was 17% for the conventional system. Better Life 1* systems with small groups (20%) and with large groups (18%) performed slightly better than the conventional system; while Canadian Bedding (15%), free-range (16%), and organic system (14%) all had a lower economic feasibility than the conventional system. The small differences among the production systems can be explained by similar levels of investment and volumes of production for the conventional system, Better life 1* systems, and Canadian bedding system. This implies that replacing the inventory required a similar amount of investment for these four production systems. The free-range and organic systems had fewer animal places due to the higher labor requirement in these systems, and therefore the investment in new inventory was lower for these systems. However, investments were also needed to provide free-range access for these systems.

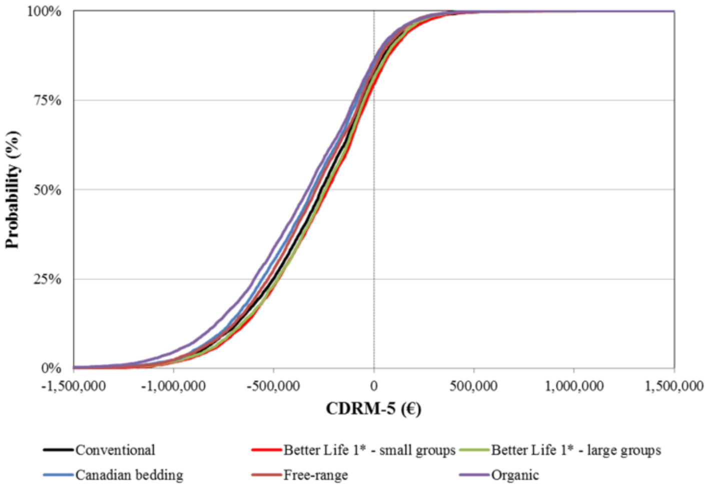

Figure 7.3 Cumulative distribution function (CDF) of the cumulative debt repayment margin at the end of the 5th year (CDRM-5) for fattening pig production systems

Sensitivity analysis

Table 7.9 presents the β coefficients for each production system in the three sectors, estimated from the stepwise multivariate regression analysis of the stochastic variables on the

CDRM-1. For all three sectors, the CDRM-1 was the most sensitive to changes in producer price (meat price in broiler and pig production and egg price in laying hen production), except for organic pig production. In organic pig production, producer prices are arranged two to four times during the year based on the cost-price, which results in a lower volatility in the producer price (Gerbers, 2013). Due to the lower volatility in this organic producer price, the effect of the organic producer price on the CDRM-1 was lower than the fattening pig sector. The sensitivity of the CDRM-1 to changes in the feed price was similar for broiler and fattening pig production. However, in laying hen production the CDRM-1 was more robust to changes in the feed price. For pig production, the piglet price had a considerable impact on the CDRM-1; while for broiler and laying hen production, economic feasibility was less sensitive to changes in the price of day-old chicks and the price of pullets. For all three sectors, the short-term economic feasibility was especially influenced by changes in market circumstances, and was more robust to changes in technical efficiency.

Table 7.9 β coefficients for the production systems in each sector, estimated from the multivariate stepwise regression of stochastic variables values on CDRM-1

Broiler production systems

Stochastic variables	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Producer price - chicken meat	1.09	1.10	1.10	1.10	1.09	1.09
Feed price	-0.54	-0.51	-0.50	-0.50	-0.44	-0.47
Weight at delivery	0.12	0.09	0.10	0.09	0.17	0.17
Feed conversion	-0.12	-0.11	-0.10	-0.10	-0.10	-0.11
Price of day-old chick	-0.06	-0.06	-0.04	-0.05	-0.04	-0.03
Mortality	-0.05	-0.04	-0.04	-0.04	-0.05	-0.04

Laying hen production systems

Stochastic variables	Multi-tiered aviary	Multi-tiered aviary with covered veranda	Multi-tiered aviary with covered veranda and	Organic
Producer price - egg	0.96	0.95	0.95	0.93
Feed price	-0.29	-0.29	-0.27	-0.32
Laying percentage	0.16	0.17	0.17	0.15
Feed intake	-0.13	-0.23	-0.22	-0.26
Pullet price	-0.05	-0.05	-0.05	-0.04

Fattening pig production systems

Stochastic variables	Conventional	Better Life 1*-small groups	Better Life 1*-large groups	Canadian bedding	Free-range	Organic
Producer price - pork meat	1.02	1.04	1.04	1.04	1.03	0.34
Feed price	-0.52	-0.49	-0.52	-0.49	-0.50	-0.66
Piglet price	-0.50	-0.48	-0.50	-0.48	-0.49	-0.55
Feed conversion ratio	-0.05	-0.04	-0.05	-0.05	-0.04	-0.03
Daily growth	0.01	0.02	0.01	0.01	0.02	-
Mortality	-	-	-0.01	-	-	-0.01

Discussion and conclusions

The aim of this study was to compare the economic feasibility of production systems with different levels of AW in three livestock production sectors: broiler, laying hen, and fattening pig production. We analyzed a farmer's choice problem of conversion to an alternative system with a higher level of AW. For this purpose, we developed stochastic bio-economic simulation models for each sector, following the methodology of Gocsik et al. (2013). These models were used to calculate the cumulative capital debt repayment margin (CDRM) at the end of the first (CDRM-1) and fifth (CDRM-5) production year after the conversion, which was defined as the indicator of economic feasibility in the short to medium term.

Results suggest that the main determinant of economic feasibility in each sector was the producer price. Sensitivity analysis showed that economic feasibility was most sensitive to changes in producer price in nearly all production systems. Therefore, it is not only the level of the price premium but also the certainty and variability of this premium that is important in the decision to convert to an alternative system. This is consistent with the finding of Gocsik et al. (2013) for broiler production systems. Studies on the economic potential of organic systems similarly found that the organic price premium is a decisive factor in farmers' income for these systems (Kerselaers et al., 2007). A survey of broiler and fattening pig farmers indicated that the majority of farmers would not convert to alternative systems if the extra costs due to higher AW standards were not compensated, i.e., in the absence of a price premium (Gocsik et al., 2014). When price premiums are absent, farmers will only convert to those systems which are economically feasible. Conversion should not increase production costs because farmers are not willing to accept negative income effects.

Assuming a price premium for products with higher AW standards, important differences were observed between the three sectors. In the broiler sector, the price premium made some of the alternative systems financially attractive. Gildehoen, Volwaard, and Puur en Eerlijk systems had a higher economic feasibility compared to the conventional system. The middle-market segment has two advantages compared to the conventional system; the farmer is financially better off and the assumed level of AW is higher. In addition, this segment has an advantage compared to the top-market segment, as these systems only require changes that are reversible in the short to medium term and that concern variable costs.

In the fattening pig sector, the economic feasibility of different systems hardly differed, which implies that farmers have no financial incentive to convert to an alternative system. However, the assumed level of AW is higher in the alternative production systems. Similar to broiler production, a clear distinction can be made between the middle-market segment and the top-market segment, based on the reversibility of the changes in the production system. Potential options to increase the attractiveness of the alternative systems for farmers include, (1) charge a higher price premium for products with higher levels of AW, and (2) provide conversion subsidies to farmers.

The laying hen sector presented no financial incentives to farmers to convert; alternative systems performed worse than the conventional production system. In this sector, a 'true' middle-market segment did not exist, as conversion to all the alternative systems would mostly involve irreversible changes. On the basis of the results, two possible approaches can be identified to increase the adoption of alternative laying hen systems. The first option is to increase the price premium to make alternative systems financially more appealing, and the second option is to develop a middle-market segment, where changes are reversible in the short to medium term. However, future research is needed to explore whether the latter option is technically feasible, and whether such systems would actually contribute to higher AW.

This study has limitations related to the availability of data and the modelling approach. Empirical data was scarce for the alternative production systems that were recently introduced to the market. Therefore, we made a number of assumptions and approximations based on expert opinion and technical reports. In addition, this study used a normative modeling approach, which ignores differences between individual farm performance, farm setup, and other farm characteristics. However, the results are representative for the average Dutch farm and therefore we consider the approach appropriate for the study objectives.

The results of the study suggest that livestock production sectors differ in terms of the prospects for improving AW. Hence, from a farm perspective, different approaches should be followed in each sector to further developing the market for products with higher levels of AW. The results imply that the broiler sector has the best perspective for developing this market in the short to medium term. In the fattening pig sector, conversion options should be made more financially attractive, for example by increasing price premiums or providing conversion subsidies. The laying hen sector has the worst perspective for improving AW in the short to medium term. Given the current production systems in this sector, producer price premiums should be increased to encourage farmers to adopt alternative production systems.

Acknowledgements

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Appendix 7

Table 7A.1 Main technical variables for the selected broiler production systems (Gocsik et al., 2013)

		Conventional	Middle-market segment			Top-market segment	
Variable	Unit	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Enrichment							
provision of grain	g/day	-	2	2	2 from 2nd week	2 from 3rd week	-
% grain in feed	%	-	Ca.70	Ca.70	Ca.70	Ca.70	-
provision of straw	Per 1,000 chickens	-	1 straw bale	1 straw bale	1 straw bale	1 straw bale	-
Stocking density at start	Chickens/m^2	19.8	14.7	16.9	13.6	13.4	8.3
Length growth period	Day	40	49	56	56	63	70
Weight at delivery	Mean (g)	2,200	2,150	2,300	2,300	2,400	2,600
	SD (g)	110	108	115	115	120	130
Daily growth	Mean (g)	55.00	44.00	41.00	41.00	38.00	37.00
	SD (g)	1.65	1.32	1.23	1.23	1.13	1.11
Feed conversion ratio	Mean (g feed/g weight)	1.69	1.94	2.09	2.09	2.25	2.60
	SD (g feed/g weight)	0.03	0.04	0.04	0.04	0.05	0.05
Mortality	Mean (%)	3.70	2.50	2.50	2.50	2.80	2.80
	SD (%)	1.07	0.73	0.73	0.73	0.81	0.81

Table 7A.2 Main technical variables for the selected laying hen production systems

		Conventional	Middle-market segment	Top-market segment	
Variable	Unit	Multi-tiered aviary	Multi-tiered aviary with covered veranda	Multi-tiered aviary with covered veranda and outdoor access	Organic
Length transition period (17-20 weeks)	Day	21[1]	21[1]	21[1]	21[1]
Length laying period	Day	392[1]	378[1]	378[1]	392[1]
Length C&D period	Day	28[1]	28[1]	28[1]	28[1]
Mortality	%	10.30[1]	12.30[1]	18.30[1]	18.30[1]
Laying percentage	Mean (%)	86.40[2]	85.60[2]	85.60[2]	75.50[1]
	SD (%)	2.80[2]	2.90[2]	2.90[2]	2.27[3]
Feed intake transition period (17- 20 weeks)	g/day	100[1]	100[1]	100[1]	110[1]
Feed intake (from 20 weeks)	Mean (g/day)	122.50[1]	124.00[1]	124.00[1]	128.00[1]
	SD (g)	6.13[4]	11.16[5]	11.16[5]	11.52[5]

[1] KWIN-V, 2011

[2] Baltussen et al., 2007

[3] Same coefficient of variation (CV) is assumed as in free-range systems, i.e., 3% (Baltussen et al., 2007). SD is calculated based on CV, i.e., SD/mean.

[4] Same coefficient of variation (CV) is assumed as in non-cage systems, i.e., 5% (LayWel, 2005). SD is calculated based on CV, i.e., CV = SD/mean.

[5] Same coefficient of variation (CV) is assumed as in non-cage systems with free range systems, i.e., 9% (LayWel, 2005). SD is calculated based on CV, i.e., CV = SD/mean.

Table 7A.3 Main technical variables for the selected fattening pig production systems

		Conventional	Middle-market segment			Top-market segment	
Variable	Unit	Conventional	Better Life 1*- small groups	Better Life 1*- large groups	Canadian Bedding	Free Range	Organic
Start weight piglet	kg	25[1]	25[1]	25[1]	25[1]	25[1]	25[1]
Finishing weight	kg	117.9[1]	117.9[1]	117.9[1]	117.9[1]	117.9[1]	117.9[1]
Carcass weight	kg	92.4[1]	92.4[1]	92.4[1]	92.4[1]	92.4[1]	92.4[1]
Used straw/sawdust	gr/animal/day	0[2]	15[2]	15[2]	400[2]	400[2]	400[2]
Mortality	Mean (%)	2.4[2]	2.1[3]	2.35[3]	2.1[3]	3.5[4]	4.5[5]
	SD (%)	0.001[2]	0.001[6]	0.001[6]	0.001[6]	0.001[6]	0.001[6]
Daily growth	Mean (g)	795[2]	825[3,7]	750[8]	825[3,7]	750[8]	733[5]
	SD (g)	5.378[2]	5.580[6]	5.073[6]	5.580[6]	5.073[6]	4.958[6]
Feed conversion ratio	Mean (kg)	2.58[2]	2.53[3]	2.70[8]	2.53[3]	2.9[9]	3.05[5]
	SD (kg)	0.034[2]	0.033[6]	0.035[6]	0.033[6]	0.038[6]	0.040[6]

[1] KWIN-V, 2012

[2] Agrovision, 2012

[3] VION, 2012

[4] Outdoor free-range access leads to an unsteady climate, which results in a higher susceptibility for infections and most likely in higher mortality (van der Peet-Schwering et al., 2008).

[5] Hoste, 2011

[6] Same coefficient of variation (CV) is assumed as in the conventional system. SD is calculated based on CV, i.e., CV = SD/mean.

[7] Vermeij et al., 2002

[8] van den Heuvel et al., 2004, personal communication with Dutch farmers.

[9] Oenema et al., 2010

Table 7A.4 Variable costs for the broiler production systems (€ per bird[1]) (Gocsik et al., 2013)

	Conventional	Middle-market segment			Top-market segment	
Variable costs	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Health care	0.045	0.036	0.036	0.036	0.036	0.120
Electricity	0.023	0.023	0.023	0.023	0.023	0.012
Heating	0.045	0.045	0.068	0.068	0.068	0.090
Water	0.008	0.008	0.008	0.008	0.008	0.016
Bedding	0.008	0.028	0.030	0.028	0.026	0.040
Catching & loading	0.039	0.039	0.039	0.039	0.039	0.039
General costs and manure disposal	0.029	0.029	0.029	0.029	0.029	0.005
Control levies organic	-	-	-	-	-	654

[1] Except for €/hour for costs of hired labor and €/year for control levies organic.

Table 7A.5 Variable costs for the laying hen production systems (€ per hen[1]) (KWIN-V, 2011)

	Conventional	Middle-market segment	Top-market segment	
Variable costs	Multi-tiered aviary	Multi-tiered aviary with covered veranda	Multi-tiered aviary with covered veranda and outdoor access	Organic - multi-tiered
Health care	0.280	0.400	0.400	-
Electricity	0.420	0.420	0.420	-
Water	0.080	0.090	0.090	-
Litter	0.030	0.030	0.030	-
Delivery	0.140	0.140	0.140	-
Placement of hens	0.080	0.090	0.090	-
General costs and manure disposal	0.582	0.587	0.587	-
Total variable costs	-	-	-	1.830

[1] Except for €/hour for costs of hired labor.

Table 7A.6 Variable costs for the fattening pig production systems

	Conventional	Middle-market segment			Top-market segment	
Variable costs	Conventional	Better Life 1*-small groups	Better Life 1*-large groups	Canadian Bedding	Free Range system	Organic
Quality discount carcass[1]	0.02[2]	0.02[2]	0.01[2,3]	0.02[2]	0.02[2]	0.02[2]
Health care[4]	1[5]	1[5]	1.05[6]	1[5]	1.36[7]	1.72[8]
Electricity[4]	1.1[5]	1.1[5]	1.1[5]	1.1[5]	1.1[5]	1.02[8]
Heating[4]	0.7[5]	0.7[5]	0.7[5]	0.7[5]	0.7[5]	0.64[8]
Water[4]	0.5[5]	0.5[5]	0.5[5]	0.5[5]	0.5[5]	0.47[8]
Overhead[4]	0.5[5]	0.5[5]	0.5[5]	0.5[5]	1.8[8]	3.1[8]
Transport to slaughter[9]	7,644[10]	7,644[10]	7,644[10]	7,644[10]	7,644[10]	7,644[10]
Manure disposal[11]	15	15[5]	15[5]	10[12]	10[12]	5.7[8]
Wood fiber/straw/roughage[13]	0.15[14]	0.15[14]	0.15[14]	0.15[14]	0.15[14]	0.15[14]

[1] € per kg carcass weight.

[2] VION, 2012

[3] Estimation based on Pijnenburg and Bens (2007).

[4] € per delivered pig.

[5] KWIN-V, 2012

[6] van den Heuvel et al., 2004

[7] Outdoor access leads to an unsteady climate, which results in a higher susceptibility for infections and thereby increases health care costs (van der Peet-Schwering et al., 2008).

[8] Hoste, 2011

[9] € per year.

[10] PVV, 2013

[11] € per ton.

Continued

Table 7A.6 (Continued) Variable costs for the fattening pig production systems

[12] Costs for manure disposal are lower compared to conventional, because these systems use more straw/enrichment materials, which results in a higher dry matter content of the manure. This leads to an increase in the disposal price (KWIN-V, 2012).

[13] € per kg.

[14] Estimation based on feed company "Balaiko diervoeders".

Table 7A.7 Replacement costs of buildings and equipment for the broiler production systems (€ per m²)[1] (KWIN-V, 2011)

	Conventional	Middle-market segment			Top-market segment	
Farm unit	Conventional	Gildehoen	Volwaard	Puur en Eerlijk	Kemper-Mais Scharrelkip	Organic
Buildings	190	190	190	190	190	190
Equipment	86	86	86	86	86	46
Covered veranda	-	-	142.5[1]	142.5 [1]	142.5 [1]	-
Outdoor access	-	-	4.8 [1, 2]	4.8 [1, 2]	4.8 [1, 2]	4.8 [1, 2]

[1] Vermeij, 2004

[2] CBS, 2012

Table 7A.8 Replacement costs of buildings and equipment for the laying hen production systems (€ per m^2)[1] (KWIN-V, 2011)

	Conventional	Middle-market segment	Top-market segment	
Farm unit	Multi-tiered aviary	Multi-tiered aviary with covered veranda	Multi-tiered aviary with covered veranda and outdoor access	Organic - multi-tiered
Buildings	190	190	190	190
Inventory	270	270	270	270
Working unit	370	370	370	370
Egg collection unit	2000	2000	2000	2000
Covered veranda	-	142.5[2]	142.5[2]	142.5[2]
Outdoor access	-	-	4.8[2,3]	4.8[2,3]

[1] Except for €/unit for egg collection unit.

[2] Vermeij, 2004

[3] CBS, 2012

Table 7A.9 Replacement costs of buildings and equipment for the fattening pig production systems (€ per m^2)

	Conventional	Middle-market segment			Top-market segment	
Farm unit	Conventional	Better Life 1*-small groups	Better Life 1*-large groups	Canadian Bedding	Free Range system	Organic
Buildings	250[1,2]	250[1,2]	250[1, 2]	250[1,2]	250[1,2]	250[1,2]
Inventory	120[1,2]	123[1,2,3]	123[1,2,3]	140[1,2]	110[1,2,4]	110[1,2,4]
Air scrubber	20[1,2]	20[1,2]	20[1,2]	20[1,2]	-	-
Free-range	-	-	-	-	100	100

[1] KWIN-V, 2012

[2] De Groot, 2013

[3] VION, 2012

[4] De Smet et al., 2009

References

Agrovision. (2012). Bedrijfsvergelijking vleesvarkens – Kengetallenspiegel. Available at http://www.agrovision.nl/sectoren/varkenshouderij/. Accessed 02-07-2014.

Baltussen, W., van Horne, P.L.M., Hennen, W.H.G.J., Wisman, J.H., van Asseldonk, M.A.P.M. (2007). Risicobarometer voor de pluimveehouderij. Rapport 2.07.11. (in Dutch with English summary). LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/25557. Accessed 23-07-2014.

Baltussen, W.H.M., Hoste, R., van der Veen, H.B., Bokma, S., Bens, P., Zeewuster, H. (2010). Economische gevolgen van bestaande regelgeving voor de Nederlandse varkenshouderij, Rapport 2010-010. LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/134934. Accessed 23-07-2014.

Barry, P.J., Ellinger, P.N. (2012). Financial Management in Agriculture 7th ed. Prentice Hall Upper Saddle River, N.J.

Bennett, R.M. (1996). People's willingness to pay for farm animal welfare. Animal Welfare, 5:3-11.

Bennett, R.M. (1997). Farm animal welfare and food policy. Food Policy, 22:281-288. DOI: http://dx.doi.org/10.1016/S0306-9192(97)00019-5.

Boerderij, 2013. Markt. Available at http://www.boerderij.nl/Opmaat/Dashboard/Inloggen/?returnurl=%2fopmaat%2fdashboard%2f%3fcmpid%3dILC%7cboerderij.nl%7cvarkenshouderij. Accessed 06-07-2013.

CBS. 2012. Statistics Netherlands. http://statline.cbs.nl/StatWeb/dome/default.aspx. Accessed 13-12-2012.

De Groot, J. (2013) Personal communication. DLV Bouw, Milieu and Techniek. Uden, the Netherlands.

De Smet, A., Bosma, B., Hoste, R. (2009). Normen voor huisvesting en arbeid voor de biologische varkenshouderij 2008. LEI Wageningen UR, Den Hague, the Netherlands. Available at http://edepot.wur.nl/1470. Accessed 03-07-2014.

Dekker, S.E.M., de Boer, I.J.M., Vermeij, I., Aarnink, A.J.A., Groot Koerkamp, P.W.G. (2011). Ecological and economic evaluation of Dutch egg production systems. Livestock Science, 139:109-121.

Den Ouden, M. (1996). Economic modelling of pork production-marketing chains. Wageningen Agricultural University, Wageningen, the Netherlands.

Dixit, A.K., Pindyck, R.S. (1994). Investment under uncertainty. Princeton University Press Princeton, New Jersey.

EC. (1999). Directive 1999/74/EC, OJ L 203, p. 53 of 3.8.1999. Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31999L0074&from=EN. Accessed 02-07-2014.

EC. (2007a). Regulation (EC) No. 834/2007, OJ L 189, p. 1 of 20.7.2007. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:189:0001:0023:EN:PDF. Accessed 08-05-2014.

EC. (2007b). Directive, 2007/43/EC, OJ L 182, p. 19 of 12.7.2007. Available at http://eur-lex.europa.eu/LexUriServ/site/en/oj/2007/l_182/l_18220070712en00190028.pdf. Accessed 08-05-2014.

EC. (2008a). Regulation (EC) No. 543/2008, OJ L 157, p. 46 of 17.6.2008,. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:157:0046:0087:EN:PDF. Accessed 08-05-2014.

EC. (2008b). Directive 2008/120/EC, OJ L 47, p. 5, 18.2.2009. Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0120&from=EN. Accessed 02-07-2014.

Ellen, H., Leenstra, F., van Emous, R., Groenestein, K., van Harn, J., van Horne, P., De Jong, I., Kense, M., Mevius, D., Wagenaar, J.A. (2012). Vleeskuikenproductiesystemen in Nederland, Rapport 619 (in Dutch with English summary). Livestock Research, Wageningen University and Research Centre, Lelystad, the Netherlands.

Fabozzi, F.J., Markowitz, H.M. (2011). The theory and practice of investment management: Asset Allocation, Valuation, Portfolio Construction, and Strategies. John Wiley & Sons Inc., Hoboken, New Jersey.

Gerbers, H. (2013). Personal commumincation. De Groene Weg. Wageningen, the Netherlands.

Gocsik, É., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2013). Mid-term financial impact of animal welfare improvements in Dutch broiler production. Poultry Science, 92:3314-3329.

Gocsik, E., Saatkamp, H.W., de Lauwere, C.C., Lansink, A.G.J.M. (2014). A Conceptual Approach for a Quantitative Economic Analysis of Farmers' Decision-Making Regarding Animal Welfare. Journal of Agricultural and Environmental Ethics, 27:287-308. DOI: 10.1007/s10806-013-9464-9.

Gocsik, É., van der Lans, I.A., Oude Lansink, A.G.J.M., Saatkamp, H.W. (2014). Willingness-to-convert to production system with improved animal welfare standards by Dutch broiler and pig farmers. Working paper. Wageningen University.

Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., Lien, G. (2004). Coping with risk in agriculture, 2nd ed. CABI, Wallingford.

Hoste, R. (2010). Economische gevolgen van meer leefoppervlakte voor vleesvarkens, Rapport 2010-012. LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/135232. Accessed 02-07-2014.

Hoste, R. (2011). Kostprijsberekening biologische varkensbedrijven. LEI, Wageningen UR, The Hague, the Netherlands. Available at https://edepot.wur.nl/164140. Accessed 03-07-2014.

Immink, V.M., Reinders, M.J., van Tulder, R.J.M., van Trijp, J.C.M., (2013). The livestock sector and its stakeholders in the search to meet the animal welfare requirements of society. Journal on Chain and Network Science, 13:151-160. DOI: 10.3920/jcns2013.1005.

Kerselaers, E., De Cock, L., Lauwers, L., van Huylenbroeck, G. (2007). Modelling farm-level economic potential for conversion to organic farming. Agricultural Systems, 94:671-682. DOI: 10.1016/j.agsy.2007.02.007.

Krekels, P. 2013. Personal communication. Slachthuis Kerkrade.

KWIN-V. (2011). Kwantitatieve Informatie Veehouderij 2011-2012. Wageningen UR Livestock Research, Lelystad, the Netherlands.

KWIN-V. (2012). Kwantitatieve Informatie Veehouderij 2012-2013. Wageningen UR Livestock Research, Lelystad, the Netherlands.

LayWel. (2005). Welfare implications of changes in production systems for laying hens, Deliverable 6.2, Report on productivity and egg quality. ADAS (partner 3), Available at http://www.laywel.eu/web/pdf/deliverable%2062.pdf. Accessed 03-07-2014.

LegManager Agrovision. (2013). Available at http://www.agrovision.nl/sectoren/pluimveehouderij/. Accessed 02-07-2014.

LEI. (2013). Bedrijfsinformatienet. Available at http://www3.lei.wur.nl/binternet_asp/. Accessed 11-03-2014.

Mollenhorst, H., Berentsen, P.B.M., de Boer, I.J.M. (2006). On-farm quantification of sustainability indicators: an application to egg production systems. British Poultry Science, 47:405-417. DOI: 10.1080/00071660600829282.

Moynagh, J. (2000). EU Regulation and Consumer Demand For Animal Welfare. AgBioForum 3, 107-114.

Oenema, O., Bikker, P., van Harn, J., Smolders, E.A.A., Sebek, L.B., van den Berg, M., Stehfest, E.E., Westhoek, H.J. (2010). Quickscan opbrengsten en efficiëntie in de gangbare en biologische akkerbouw, melkveehouderij, varkenshouderij en pluimveehouderij. Werkdocument 182. Wettelijke Onderzoekstaken Natuur & Milieu, Wageningen UR, Wageningen, the Netherlands. Available at http://edepot.wur.nl/239910. Accessed 03-07-2014.

Oosterkamp, E.B., Bremmer, B., Hoste, R., De Greef, K.H. (2011). Verkenning van dierlijke tussensegment in onze buurlanden: Duurzam varkensvlees, pluimveevlees en eieren, LEI-rapport 2011-028 (in Dutch with English summary). Landbouw-Economisch Instituut, Den Haag, the Netherlands.

Pijnenburg, J., Bens, P. (2007). Economische berekening netwerkgroep grote groepen vleesvarkens. DLV Intensief Advies BV, Uden, the Netherlands.

Pindyck, R.S. (1991). Irreversibility, Uncertainty, and Investment. Journal of Economic Literature, 29:1110-1148.

PVE. (2013). Statistisch Jaarrapport pluimveevlees en eieren 2012 voorlopig. Dutch Product Boards for Livestock Meat and Eggs, Zoetermeer, the Netherlands, Available at http://www.pve.nl/wdocs/dbedrijfsnet/up1/ZkwzyjvIC_statistischjaarverslag2012.pdf. Accessed 03-07-2014.

PVV. (2013). Landelijk Biggenprijzenschema. Available at http://www.pve.nl/wdocs/dbedrijfsnet/up1/ZssflbxIG_BPS_in_te_leveren_excl_BTW_juli13.pdf. Accessed 03-07-2014.

Quinten, S. (2013). Personal communication. Meat Friends, Roosendaal.

Roex, J., Miele, M. (2005). Farm Animal Welfare Concerns, Consumers, Retailers and Producers. Available at http://www.welfarequality.net. Accessed 03-07-2014.

Spreeuwenberg G. (2013). Personal communication. VION Food Group, Boxtel.

Van den Heuvel, E.M., Hoofs, A.I.J., Binnendijk, G.P., Bosma, A.J.J., Spoolder, H.A.M. (2004). Grote groepen vleesvarkens. Effects of group size on fattening pigs. PraktijkRapport Varkens 29. Animal Sciences Group, Lelystad, the Netherlands. Available at http://edepot.wur.nl/29371. Accessed 03-07-2014.

Van der Peet-Schwering, C.M.C., Kuijken, N., Raymakers, R.A., Stockhofe, N., Van Leengoed, L.A.M.G., Binnendijk, G.P., Cruijsen, T., Augustijn, M. (2008). Effects of less animal contacts on pleuritis in growing and finishing pigs, Rapport 111 (in Dutch with English summary). Animal Sciences Group, Wageningen UR, Lelystad, the Netherlands. Available at http://edepot.wur.nl/29051. Accessed 03-07-2014.

Van Horne, P.L.M. (2012). Competitiveness of the EU egg industry, Report 2012-065. LEI Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/239093. Accessed 03-07-2014.

Vanhonacker, F., Verbeke, W. (2014). Public and Consumer Policies for Higher Welfare Food Products: Challenges and Opportunities. Journal of Agricultural and Environmental Ethihcs, 27:153-171. DOI: 10.1007/s10806-013-9479-2.

Veissier, I., Butterworth, A., Bock, B., Roe, E. (2008). European approaches to ensure good animal welfare. Applied Animal Behaviour Science, 113:279-297. DOI: 10.1016/j.applanim.2008.01.008.

Vermeij, I. (2004). Primaire productiekosten biologisch kuikenvlees. Intern Rapport 505. Wageningen UR, Animal Sciences Group, Lelystad, the Netherlands.

Vermeij, I., Hoofs, A.I.J., Enting, J. (2002). Vergroot leefoppervlak voor vleesvarkens bij 2 koppelgroottes. PraktijkRapport Varkens 9. Praktijkonderzoek Veehouderij, Lelystad, the Netherlands. Available at http://edepot.wur.nl/34310. Accessed 03-07-2014.

Vermeij, I., Van Horne, P.L.M. (2008). Kostprijs biologische vleeskuikens, Rapport 170. Animal Sciences Group Wageningen University, Lelystad, the Neherlands.

VION. (2012). VION Good Farming Star: Technical results. VION, Boxtel, the Netherlands

Chapter 8

General discussion

Introduction

Minimum guidelines concerning animal welfare (AW) are specified in the laws of the EU and national governments in most European countries. Within the current international economic and political environment further improvements in the welfare of farm animals predominantly rely on market initiatives that set above-legal AW standards (Vanhonacker and Verbeke, 2014). In this regard, roughly three market segments emerge along the AW spectrum, i.e., conventional, which complies with minimum legal standards, a middle-market segment which supplies products that go beyond conventional standards but do not meet organic standards, and a segment which supplies organic products and products that are comparable with those in terms of AW standards. By definition, implementation of above-legal standards in the farm is a voluntary choice of the farmer.

The overall objective of this dissertation was to analyze the factors that determine farmers' decision-making with regard to the implementation of above-legal AW standards, and to identify barriers to the adoption of above-legal AW standards at farm level. This dissertation focused particularly on farmers' choice with regard to adopting an AW system that complies with the demands of the middle-market segment. The overall objective was split into four sub-objectives and addressed in Chapters 2-7. Chapter 2 developed a conceptual approach for the analysis of farmers' decision-making related to improved AW on the basis of available literature. This chapter provided a scientific basis for subsequent analysis, which focused on two main areas (1) farmers' preferences and choice-making, and (2) the financial impact of the decision. Chapter 3 addressed farmers' intrinsic motivation to improve AW in broiler and fattening pig production by eliciting farmers' preferences about AW-related characteristics of a production system. Chapter 4 explored broiler and fattening pig farmers' choice with regard to a production system and the necessary conditions to convert to a production system with improved AW. Following, Chapter 5, 6 and 7 analyzed the financial impact of the adoption of production systems with improved AW. Chapter 5 studied the medium-term economic feasibility of different broiler production systems in the Netherlands using bio-economic modeling techniques. Chapter 6 further zoomed in on broiler production and analyzed animal health care costs in different broiler production systems. Chapter 7 developed bio-economic models for laying hen and fattening pig production drawing on the methodology of Chapter 5, which enabled a comparison between the broiler, laying hen, and fattening pig production sectors in terms of their economic feasibility.

This concluding chapter discusses the overall results in a wider context, elaborates implications for business stakeholders and policy makers, reflects on the methods used in this dissertation, outlines directions for future research, and finishes with the main conclusions of the dissertation.

Synthesis

In this dissertation the farmer, a decision-maker who faces a voluntary choice of implementing above-legal AW standards is the central topic of interest. Chapter 2 hypothesized that the farmers' decision related to implementation of above-legal AW standards is a multi-objective decision problem. A substantial body of literature holds that in general farmers' strategic decisions cannot solely be explained by a single category of reasons, such as financial ones, but rather by a mix of factors including e.g., social relations and moral considerations besides the financial considerations (Ohlmer et al., 1998; Willock et al., 1999; Schoon and te Grotenhuis, 2000; de Buck et al., 2001; Edwards-Jones, 2006). Hence, in Chapter 2, a general framework was developed based on literature and expert discussions. In this framework, farmers' decision-making was conceptualized as a process in which farmers trade off financial and non-financial goals. Financial goals relate to monetary aspects, whereas non-financial goals appeal to farmers' intrinsic motivation to improve AW. Intrinsic motivation concerns farmers' internal reasons for undertaking a particular action and appeals to farmers' moral obligation (de Young, 1996). However, from Chapter 3 it appeared that the decision-making by Dutch broiler and pig farmer regarding AW is primarily driven by financial motives. More specifically, findings in Chapter 3 suggested that the average Dutch broiler and fattening pig farmer, characterized as a farmer operating a medium- or large-sized farm according to conventional production standards, does not have a strong intrinsic motivation to adopt above-legal AW standards. On the basis of a large transnational survey in nine EU countries and Switzerland, Wilson and Hart (2000) also found that financial reasons are the primary driving force for farmers to participate in agri-environmental schemes. The fact that financial factors get more emphasis in farmers' decision-making regarding AW can be explained by several reasons. Over the recent decades, consolidation took place in poultry and fattening pig farming which led to the current farming structure (Grabkowsky et al., 2007). On the one hand, there are a few small farms that often produce according to organic standards and target niche markets. On the other hand, the majority of farms produce according to the legal minimum standards and target the bulk market. A high concentration of these latter category of farms results in a high internal competition at producer level; farmers are pressured to improve on efficiency rather than on other aspects such as AW (Dobson et al., 2003). Further, farms already operate on a very tight and volatile profit margin which leaves farmers with little scope for considering other than financial aspects (Hoste et al., 2004; Verspecht et al., 2011; van Horne, 2012). Giving way to non-financial goals in the decision-making can, thus, jeopardize the continuation of the farm business. In addition, the most common business forms in agricultural production are sole proprietorship and partnership. These business forms imply that farmers are personally liable for the entire amount of any business-related obligations, therefore business decisions can also put farmers' private properties at risk (van der Veen et al., 2007).

Chapter 3 also highlighted that within the current market conditions farmers' choice is the conventional system. However, Chapter 4 suggested that farmers are not entirely reluctant to change their production system. Often farmers were willing to convert to alternative systems if they could maintain their income at the current level. Hence, these findings imply that for the majority of farmers the drive to improve on-farm AW has to come from outside the farm by providing financial incentives for the adoption of alternative systems. The necessity of incentive systems to motivate farmers to adopt measures that impose cost disadvantage at the farm level was also stressed by Valeeva (2005) in the case of additional food safety measures at dairy farms. Te Velde et al. (2002) suggested that financial incentives are just as important for consumers as for farmers, i.e., although consumers usually have negative associations about livestock production, most of them tend to buy the cheapest in the supermarket. Because financial aspects appeared to dominate farmers' decision-making, they are studied in detail in Chapter 5 to 7. It appeared that currently the pig and laying hen sector present no financial incentives to farmers to convert, whereas in the broiler sector price premium makes some of the alternative systems financially attractive to farmers (Chapter 5 and 7). Chapter 5 and 7 provided useful insights to set the focus of the incentives with regard to AW. In case of all three livestock sectors, i.e., broiler, laying hen, and fattening pig, it is obvious that price premium is the main determinant of economic feasibility of alternative production systems complying with above-legal AW standards. It is not only the *level* of the price premium but also the *certainty* of this premium that is important in the decision to convert to an alternative system. This is in line with the findings of Bornett et al. (2003), which underline the importance of price premium for ensuring long-term viability of pig farms producing under higher AW standards. Kerselaers et al. (2007) also found that price premium is a decisive factor for organic farmers' income.

In Chapter 7 alternative production systems are classified according to whether the investments that farmers are required to make to their current production system are reversible or irreversible. Reversible investments mainly affect variable costs, so the conventional farming practice can easily be restored. In contrast, irreversible investments involve large changes to the farm, which limits the flexibility of farmers to revert to the conventional farm situation. In this regard, Chapter 4 showed that that this distinction is highly relevant to farmers as both broiler and fattening pig farmers were more willing to adopt systems requiring reversible investments compared to systems requiring irreversible investments, such as covered veranda and outdoor access. This finding is in line with Franz et al. (2010), who also suggest that farmers only implement irreversible investments if they see potential for long-term profit or if they have a strong intrinsic motivation. In addition, the preference for reversible investments can also be explained by the fact that most farmers are risk averse (Hardaker et al., 2004). In this regard, reversible changes allow farmers to experiment with the innovation on a trial basis as the conventional farming practice can easily be restored. During the trial period farmers seek information on the cost and the value of the innovation from their own and other users' experiments (Marra et al., 2003). Many studies highlighted the key role of trialing in innovation adoption to reduce perceived uncertainty regarding costs and benefits of the innovation and to allow farmers to improve skills (Padel, 2001; Marra et al., 2003; Ghadim et al., 2005).

Chapter 6 analyzed production costs in different broiler production systems with a particular reference to animal health care costs. The study concluded that, although differences in animal health care costs exist across production systems, the effect of animal health care costs on farmers' strategic decisions regarding the production system is most likely to be outweighed by other costs. Hence, animal health care costs are most likely less important in the decision-making to convert to an alternative system.

Chapter 5 and 7 also provided insights on production costs. Findings showed that higher AW standards usually increase production costs. Given that earning a price premium which at least covers the extra costs is a decisive factor in farmers' decisions, but is in farmers' view very uncertain (Chapter 4), the cost-efficiency of improving AW is of high importance for farmers as well as for retailers and consumers. In other words, alternative systems which realize the highest relative increase in AW at the lowest costs are preferred. As part of this research, a preliminary study on broiler production analyzed the cost-efficiency of selected alternative production systems (Brooshooft, 2014). Cost-efficiency was defined as ratio of change in the level of AW (compared to the default conventional system) and change in total production costs (compared to the default conventional system). The level of AW at farm level, indicated as an index score, was estimated on the basis of Welfare Quality® protocol (Welfare Quality®, 2009). The Welfare Quality® protocol is developed by a large number of research groups and institutes to provide a standardized way for measuring AW. Hence, that represents a scientific opinion concerning AW. The results of the preliminary study showed that middle-market systems, such as Volwaard and Puur en Eerlijk, have the highest cost-efficiency compared to outdoor and organic broiler production systems (Figure 8.1).

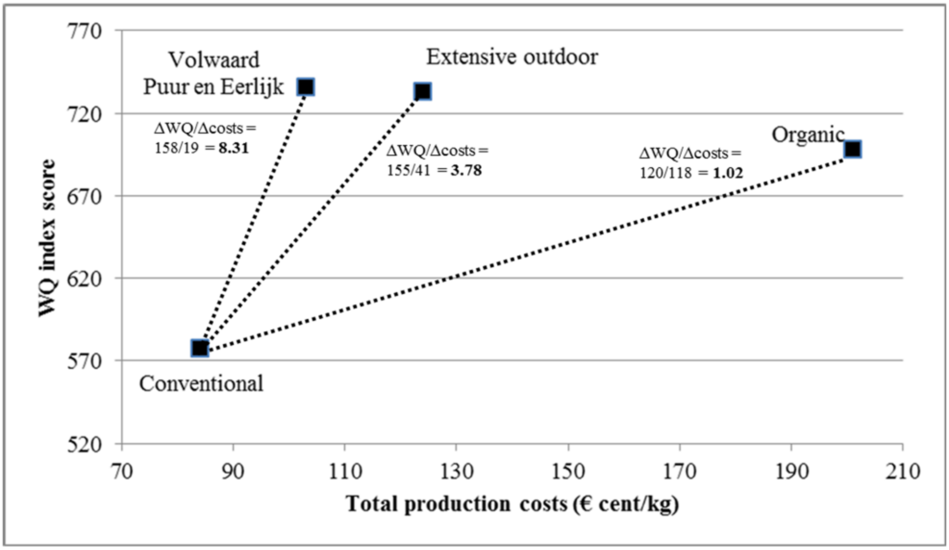

Figure 8.1 Production costs and WQ index scores per production system

The cost-efficiency of the Volwaard and Puur en Eerlijk system is 8.31, that of the Extensive outdoor system is 3.78, and that of the Organic system is 1.02. The study underlined that middle-market systems improve on those components of the production system that have relatively high contribution to the level of AW, such as broiler type (breed), stocking density and length of dark period. Whereas in outdoor and organic systems the increase in costs compared to the increase in the level of AW resulted from further improvements, such as outdoor access and length of growth period is disproportionate. The attributes that scored high in terms of their contribution to AW in this preliminary study, such as broiler type and stocking density, are also considered as of high importance for AW in other literature (Bokkers, 1997; Maurice et al., 1999). Hence, it appears that although farmers prefer the conventional production system, the middle-market segment offers perspectives in the short to medium-term to increase AW at relatively low costs in the farm. Nevertheless willingness-to-pay of the consumer for animal-friendly products and commitment from retail are required.

In conclusion, this dissertation underlined that at farm level, certain financial preconditions have to be met to enable farmers to adopt higher AW standards. More specifically, farmers require a price premium that is at least sufficient to cover extra costs as a result of higher AW standards. Furthermore, it is important to manage the (perceived) uncertainty of the market and price premiums. These imply that middle-market systems could be attractive for farmers due to their high cost-efficiency, i.e., realize the highest relative increase in AW at the lowest costs, which is also in the best interest of other stakeholders in the supply chain and also consumers as in general they also seek to minimize costs. Furthermore, as switching to a middle-market system mainly affects variable costs, farmers are given the flexibility to revert to the conventional system if their expectations are not met or to switch to a more attractive system which might in the meantime appear. In the light of the foregoing, further development of the middle-market segment appears to be a sensible direction in improving AW.

Business and policy implications

In order to facilitate the further development of the middle-market segment, a high involvement and commitment of all stakeholders in the supply chain, i.e., slaughterhouses, processors, retail, NGOs, and the government is required (Immink et al., 2013). In the following, the role of different stakeholders is discussed.

In case farmers convert to middle-market systems, production costs increase to some extent. As findings of this dissertation showed that farmers are not willing to take the negative income effect, price premiums have to be charged to compensate farmers for the extra production costs. Findings also suggested that it is not only the *level* of the price premium, but the *certainty* of the premium plays also an important role in farmers' decision-making. Since producer price premium most likely translates into higher consumer prices, *consumers*' willingness-to-pay and whether willingness-to-pay is maintained in the long-term are important. Consumers differ in their perceptions towards AW and this influences the extent how much they are willing to pay for different product traits. De Jonge and van Trijp (2014) suggest that half of the consumers takes a more comprehensive view in their perceptions of AW, i.e., consider many attributes to form an opinion of the animal friendliness of a production system. In contrast, the other half takes a more heuristic approach by viewing animal friendliness from a uni-dimensional perspective (animal space vs. slaughter method). Consumers' willingness-to-pay ultimately sets the *level* of price premium. The *certainty* of the price premium depends on whether consumers' willingness-to-pay is maintained in the long-term, i.e., how strong consumers' intrinsic motivation towards AW is.

At the *retail* level, supermarkets are the most important channel for distributing meat and meat products. Supermarkets represent a highly concentrated buyer group (Houwers et al., 2004). In 2012, for meat, the supermarkets' share amounts to 59%, while for meat products it amounts to 81% (PVE, 2013). Features of the assortment offered by the retail may also influence consumers' willingness-to-pay. More specifically, regarding the assortment the minimum AW level in the shop, i.e., whether there are conventional products available and also the difference between the price of the conventional product and that of the animal-friendly alternative are of importance. In this respect, to maintain consumers' long-term willingness-to-pay a change in the attitude of retail toward livestock products, particularly meat products, is needed.

In addition, supermarkets' current practices do not encourage producer investments where fixed costs cannot be recovered (Dobson, 2002). Often supermarkets set low margins or even make losses on certain meat products, such as pork and poultry meat in order to attract more consumers in their stores (OECD, 2006). Sales of promotional activities at the supermarkets amount to 40% of total turnover in pork production (EU, 2011). These promotions are favorable to the overall retail turnover as they generate traffic for other products, which are sold with higher margins. Nevertheless, they are detrimental to the meat supply chain parties. Due to the weak relations between supermarkets and suppliers, supermarkets have the freedom to choose the suppliers offering the lowest price. These activities, therefore, put pressure on the margins of the supply chain players. Also, they generate high internal competition among the farmers and force them to sell their products at a price which only covers their (short-term) marginal costs, but is not sufficient to recover the long-term fixed costs. On top of that, these promotions mostly target the conventional product assortment and, in turn, lead to an un-proportionately high price difference between conventional and animal-friendly products. Hence, to provide incentives for farmers to improve AW, a different attitude is needed from the supermarkets. That has certain implications for pricing in particular, i.e., market price should reflect the total social costs incurred throughout the entire supply chain (van Drunen et al., 2010).

By definition, social costs include the market price, externalities which are costs rising from the unintended side effects of meat production, and subsidies given to the industry. These promotions ignore the fact that livestock production produces negative externalities, such as animal suffering due to the low level of AW (Lusk, 2011). In that sense, animal suffering (or infringement on AW) represents a cost that is currently ignored in the price of meat. By including externalities in the price as much as possible, it would enable farmers to accumulate funds for investing in innovation in the long run and thereby to reduce externalities. However, it needs to be recognized that at the same time such a price increase may lead to a decrease in the overall demand, which in turn can negatively affect the stakeholders at the supply side. Furthermore, relations between retail and suppliers and thus farmers should be strengthened by giving certain guarantees to farmers, such as minimum price guarantee or preferred supplier status (Shaw and Gibbs, 1995; Kolk, 2005).

The development of a middle market segment sets demands for *slaughterhouses* and *processors* as well. Their primary role is seen in the organization and certification of the supply as they need to create a separate chain and to build sufficient capacity for handling, processing and marketing products with higher AW (Franz et al., 2010). Besides the fact that slaughter and processor companies need to make additional costs in order to manage a differentiated supply of products, recent events suggest that it is easier said than done. A recent scandal in the meat industry came to light which claimed that conventional meat was purposely mixed with animal-friendly meat at the processing stage and was sold as animal-friendly meat to the retail and, in turn, to the consumer (NOS, 2013). Although, so far these claims proven not to be true, they suggest that creating different supply chains adds much complexity to processing and also to certification. Furthermore, such scandals can seriously undermine consumers' trust in animal-friendly products, which most likely negatively influences their willingness-to-pay. In addition, slaughterhouses and processing industry are the direct buyers of the farm products. Hence, they have an important role in farm risk management as they can provide farmers with certain guarantees thereby reduce farm-level risk.

Besides the domestic market, export markets are of great importance for the Dutch production of pork and poultry. In 2011, the Netherlands exported pork meat accounted for 67% of domestic supply and broiler meat accounted for 113% of domestic supply to European markets and to some extent beyond (PVE, 2011). For pork meat, the main export markets were Italy (18%), Germany (16%), and Greece (13%) accounting for about half of the total pork meat export in 2011 (PVE, 2011). For broiler meat export, in 2012 the main destinations were western European countries, such as Germany (32%), UK (20%), and France (9%) (PVE, 2011). Regarding export markets, the main issues are whether these export markets are featured by consumer trends similar to those in the domestic market and whether developments in retail and processing are consistent with the characteristics of the Dutch market. In that sense, export markets offer opportunities to various extent for the middle-market segment (Oosterkamp et al., 2013). In Germany, developments of a middle-market segment are in an early stage (Oosterkamp et al., 2011). However, since 2011 new market initiatives have been introduced to establish a middle-market segment due to growing consumer awareness on AW. In the UK, the middle-market segment for animal-friendly products is well-developed. For the British consumer, AW is an important aspect of a more integral concept of sustainability. In that sense, both Germany and the UK offer potential for Dutch export of middle-market products with improved AW. In France, there is great variation in the meat assortment. However other issues, such as taste and quality, rather than AW, are in the focus of attention and these are the issues that primarily drive consumer demand. In southern European countries, such as Italy and Greece, AW concerns are less pronounced (Ingenbleek et al., 2013). In this regard, these latter three countries offer a little scope for trade of middle-market products. Hence, focus should be placed on North-Western Europe, particularly Germany and the UK.

Upgrading of livestock production towards higher AW by emphasizing middle-market segments can be stimulated by NGO's and also by the government. In the Netherlands, *NGO's*, mostly animal interest groups, have undertaken an active role in the recent developments of the market for animal-friendly products. For example, in recent years Wakker Dier, one of the Dutch AW organizations, have been pursuing intensive media campaigns to push processing companies and supermarkets to stop with supplying and selling conventional livestock products and increase their minimum AW standards (Wakker Dier, 2014). Furthermore, the Dutch Society for the Protection of Animals (DSPA) was involved as a leading party in market creation for AW (Bos et al., 2013). In that sense, different NGO's follow different strategies to serve the common interest of improving AW. Their main function is not only to raise, but also to maintain public awareness on AW issues as the middle-market segment provides the flexibility for both farmers and consumers to reverse to conventional products. Also, they have a role in initiating new market concepts, increasing the minimum standards, and bringing society's view closer to the industry.

As for the *government's* involvement, they can facilitate middle-market developments either through legislation to increase legal minimum standards or using other policy instruments, such as taxes and subsidies. Studies suggest that in the near future minimum standards will most likely not be increased at the Dutch national and EU level (Vanhonacker and Verbeke, 2014). Policy instruments, such as taxes and subsidies to deal with production externalities have been widely studied. Lusk (2011) points out that tax on meat consumption alone to offset the costs of the negative externality would probably not be effective in improving AW. The study highlights that as the general idea is that the tax on meat would reduce intake of meat, the primary effect of tax would be on the quantity of animals living not on the quality of animal lives. Harvey and Hubbard (2013) argue if public subsidies are warranted temporary consumption subsidies are more appropriate than production subsidies, as they would be only paid to the extent of that consumption (rather than the total production) of animal friendly products actually increases. In addition, these subsidies are more consistent with international trading obligations (Ingenbleek et al., 2013). Harvey and Hubbard (2013) consider AW as a private rather than a public good, determined by the consumption of animal products. Therefore they see the government's involvement as necessary in the provision of reliable information, third party verification standards and R&D to develop more AW friendly production systems.

Animal welfare can be conceived as part of a broader context as it is only part of the whole set of traits of the livestock production, such as environmental impact and additional product quality aspects. Changes in one aspect often have implications for one or several more aspects. For example, free-range systems are considered to positively contribute to animal welfare, but they usually result in a greater environmental impact than conventional indoor systems (Leinonen et al., 2012). Livestock production is a dynamic system, therefore relations between different aspects should be considered. Hence, animal welfare policies should be embedded in a comprehensive framework that integrates the various aspects of livestock production. Stakeholders often prioritize issues differently (Olsson et al., 2006), which makes the development of a comprehensive policy framework complex.

Finally, various stakeholder groups often have different interests in improving AW (Vanhonacker and Verbeke, 2014) and also different views on the way to improve animal welfare. There are parties that support initiatives that gradually improve on AW over the years, e.g., DSPA, and those that prefer an immediate drastic change, e.g. Wakker Dier. Recently, one of the Dutch supermarket chains introduced broiler meat with improved AW (Veerman, 2014). The introduction of the new product received significant media attention particularly because of the criticism of Wakker Dier on the supermarkets media campaign. Wakker Dier naturally would prefer to see a more drastic change in AW. However, this dissertation suggests that intermediate initiatives are crucial for farmers and also for other stakeholders due to the complexity of the issue. The lack of unified support from different stakeholders can ultimately impair consumer trust in AW initiatives as a whole.

Approach and methods

Multi-disciplinary approach

Farmers' decision-making related to the implementation of higher AW standards concerns a multi-objective decision problem constrained by a wide range of external and internal factors. Consequently, to address the various aspects of decision-making a multi-disciplinary approach is needed. The conceptual framework developed in this dissertation (Chapter 2) was useful to identify the various disciplines including economics, social-psychology, and consumer behavior, that are used throughout the dissertation. The multidisciplinary nature of the research also shows within the different chapters, for example the bio-economic models in Chapter 5, 6 and 7 require inputs from a wide range of disciplines including animal welfare, animal health, animal husbandry, economics and marketing.

The dissertation combined two principal research approaches: farmer survey and simulation modeling, which complemented each other. The farmer survey (Chapter 3 and 4) focused particularly on the questions (1) what is expected by the famers in terms of e.g., income and system characteristics, and (2) whether farmers have particular preferences for any of these aspects. Whereas the simulation modeling (Chapter 5 to 7) aimed to assess the potential economic impact and feasibility of various production systems with improved AW within the current market and technological conditions. The combination of these two approaches enabled to identify the potential gaps between the feasibility of AW systems and expectations towards these systems and to determine the main focus areas to increase adoption of on-farm above-legal AW standards in the future. The approach was developed to analyze farmers' decision-making particularly on AW. However, this approach can be applied to other issues to where trade-off is made between financial and non-financial aspects, for example in the analysis of corporate social responsibility. In the following, the main methodological choices and data issues are discussed.

Farmer survey

A survey research was conducted to explore the Dutch broiler and fattening pig farmers' intrinsic motivation to improve AW and their willingness-to-convert to alternative systems (Chapter 3 and 4).

Sampling and distribution of the questionnaire

In the Netherlands, 564 broiler farms and 4,548 fattening pig farms operated in 2013 (CBS, 2013). A special feature of the population is that the majority of broiler and fattening pig farmers pursue intensive farming in a medium- to large farm specialized in the production of a single animal species (Baltussen et al., 2010; Ellen et al., 2012). Our primary interest was in eliciting the views of this particular group of farmers as they represent the main group of potential adopters of alternative systems. Given the large number of individuals in the population, sampling was inherent to conduct the survey research due to limited resources available, such as time and money. Convenience sampling a non-random sampling method was used in this study (Hernon, 1994). In convenience sampling, researchers include participants in the sample who are readily available and agree to participate in the study (Babbie, 1990). In addition, researchers have to ensure that the sample represents the population they want to learn about. On this basis, we narrowed down the study area to Noord-Brabant as we were interested in a specific group of farmers, i.e., conventional farmers who pursue intensive farming in a medium- to large farm specialized in a single animal species. Noord-Brabant, a province located in the southern part of Netherlands, is densely populated with conventional farms and represents the main production area of poultry and pigs in the Netherlands (Baltussen et al., 2011).

Although in quantitative studies random sampling is usually preferred over non-random sampling, in this study random sampling was not possible due to time constraints and the nature of the questionnaire. More specifically, the questionnaire to collect data from farmers included a conjoint task and a contingent valuation task. Farmers have most likely never encountered these kinds of questions and thus they might have appeared somewhat “strange” to farmers at the first sight. Hence, the questions required a detailed explanation. Therefore, we sought personal contacts with the farmers to distribute the questionnaire. In case of random sampling, respondents would have most likely been located far from each other all over the country. Hence, the preferred way of distributing the questionnaire had been via post due to time and budget constraints. Consequently, this method of distribution would have implied of risking a high rate of non-response and potential misinterpretation of the questions, which would ultimately affect the accuracy of results. In contrast, conveniences sampling enabled us to contact the farmers in person and explain the questionnaire. In addition, farmers usually have limited time to research activities and it is difficult for them to fit these activities in their everyday routine. Hence, study groups which serve as a forum for farmers to regularly discuss their experiences and new possibilities among other farm-related issues appeared a suitable choice for distributing the questionnaire for two reasons. First, these meetings enabled us to interact with farmers and make sure that they have a proper understanding about the questions. Second, these regularly scheduled meetings were a good opportunity to reach a relatively large group of farmers (10-15 farmers). In conclusion, in this study convenience sampling fitted better than random sampling techniques considering the characteristics of the study population, the nature of the study, and the resources available to conduct the study.

Representativeness of sample

In total 22 broiler farmers from three study groups and 15 pig farmers from three study groups participated in the studies. The sample consisted of farmers who had on average a medium- or large-scale farms. The main source of family income was the farm, which had been intensively expanded over the last five to ten years. The respondents represented approximately 12% of the broiler farmers and 1% of the fattening pig farmers in Noord-Brabant. Although the sample appeared to be quite a homogeneous group in terms of farm characteristics, preferences, and willingness-to-convert to alternative systems, the generalizability of the results had to be considered with care for two reasons. First, a non-random sampling requires a more careful investigation of the generalizability of the results. Second, the relatively small sample size reduces the extent to which the results can be generalized to a larger population, even to the specific study area the sample was drawn. Therefore, a workshop with a panel of experts including veterinarians, farm advisors, and other professionals in the broiler and fattening pig sector was held to check the representativeness of the farmer sample. Experts confirmed that the main findings of the survey hold for the majority of Dutch broiler and fattening pig farmers. In terms of farm characteristics, a few differences between the study area and the rest of the country were indicated. Consequently, results might not be applicable to smaller and less specialized farms. However, a large proportion of meat production comes from specialized medium- and large-scale farms, which were represented in the study.

Simulation modeling

A normative modeling approach

In Chapter 5 to 7, the aim was to analyze financial aspects of improved AW standards in different livestock production systems. Livestock production systems are highly complex systems. Simulation models are appropriate for modeling highly complex systems as they represent a system in terms of logical and quantitative relationships that can be changed to see how the model reacts, and thus how the actual system would react (Law and Kelton, 1991). Simulation models can be stochastic which means that uncertainty is incorporated, or deterministic. This dissertation used both stochastic and deterministic techniques.

Stochastic simulation models were used in Chapter 5 and 7 to assess the economic feasibility of different broiler, laying hen, and fattening pig production systems. Simulation modeling is a normative tool for economic evaluation which involves certain assumptions about the behavior of the decision maker, i.e., farmer (Janssen and van Ittersum, 2007). Chapter 5 and

7 used the cumulative debt repayment margin at the end of the 5th year after the investment (CDRM-5) to compare the economic performance of different production systems. Capital debt repayment margin refers to the amount of money that remains after all the operating expenses have been paid. Inherently, the farmer was assumed to make his decision based on CDRM-5. In addition, the system was considered economically feasible if the CDRM-5 was greater than or equal to zero. Hence, although this criterion provided an objective measure to compare the production systems, it did not account for differences in farmer's characteristics such as income and risk attitude. Farmers might choose lower or higher cut-off points depending on their financial situation and risk attitude (Hardaker et al., 2004). Although choosing a lower or higher cut-off point in most cases does not influence the ranking between production system, it influences the absolute judgment of economic feasibility. The normative approach used in Chapter 5 and 7 fitted the purpose of the research which was to assess the risk profile of various production systems and thereby facilitate farmers' decision-making rather than to give the farmers the final decision.

Chapter 6 presented a deterministic economic model to study the economic effect of a disease in different broiler production systems using partial budgeting technique (Dijkhuizen and Morris, 1997). For this purpose, the model described in Chapter 5 was adapted. The model was adjusted with technical, economic, and veterinary inputs, such as disease prevalence and impact. Following (McInerney et al., 1992), animal health care costs were defined as the sum of losses and expenditures. Losses can be caused, for example, by mortality and reduced production efficiency, which results in reduced returns. Extra expenditures are mainly the costs of veterinary prophylactics and therapeutic treatments to prevent or treat the disease. This definition enabled to consider all economic effects of a disease in the farm in the calculation of health care costs. The models in Chapter 5, 6, and 7 were represented average Dutch farms, however the parameters of the model can be adjusted to reflect other types of farms. Moreover, the main findings are relevant to many Western-European countries, particularly Germany, Great Britain, Belgium, and France, in which farmers face a similar decision problem, i.e., a choice of switching to an alternative production system or not.

Data issues

Simulation models highly draw on input data. Data for conventional systems were typically available, however data related to alternative production systems recently introduced to the market were scarce. Therefore, a number of assumptions and approximations were made based on different data sources such as scientific literature, technical reports and expert opinion.

Chapter 5 and 7 used bio economic simulation modeling which requires data on biological and economic parameters of the systems. Data related to the average production performance of the systems were in most cases available in literature. However, data related to the variation in production performance in alternative systems were often lacking, and estimations were made based on the production performance of conventional system. As for the economic parameters, data on price premiums for products with higher AW were usually not available in literature. These price premiums, thus, for the broiler systems were derived from consumer prices without accounting for the possibility that food processing companies and retail entities might operate with different margins for AW-friendly products than for conventional products. In Chapter 5 to account for uncertainties in estimating price premiums, scenario analysis was conducted to investigate different levels of and variations in the price premiums. For estimating price premiums related to fattening pig systems expert opinion was used (experts that work in the pig industry).

Similarly, different data sources were used for parameterizing the partial budgeting model in Chapter 6. Veterinary inputs, such as disease prevalence and impact were not available in peer-reviewed scientific literature for all systems, so the modeling approach involved certain assumptions and estimations. The final parameters were critically reviewed by an expert in poultry diseases to be able to provide the most accurate results.

Validity of results

In the case of building simulation models, verification and validation of the model are crucial steps. Verification is the process of ensuring the model operates as intended (Banks, 1998). Simulation models were verified by examining the model output under a variety of settings of the input parameters whether they are reasonable compared to the available knowledge on the systems. Validation is defined as determining whether the simulation model is an accurate representation of the real system (Kleijnen, 1999). A common way to validate a model is to compare model outputs to the outputs of the real system. However, in the case of recently introduced production systems real data were often not available. Sensitivity analysis considered an appropriate tool for model validation as it is used to determine the robustness of the results to changes in input parameters (Hamby, 1994; Pannell, 1997). Model validation was performed using real data when it was available and conducting comprehensive sensitivity analyses to examine whether model results were robust to changes in input parameters (e.g., Chapter 5).

Implications for future research

This dissertation focused on the on-farm decision-making on AW. However, AW is only a single category of issues that raises concerns with regard to modern livestock production. Concerns regarding environmental impact, animal health, food safety, antibiotic use among several others are also important topics in social debates (Tilman et al., 2002). These topics are often interlinked (McGlone, 2001). Hence, changes in one aspect have implications for another one. For example, improvements in animal health have a potential positive impact for animal welfare, such as the animal is able to move better. Hence, future research should consider AW in a broader context, with particular regard to potential interactions among the several dimensions of livestock production. Such an integrated approach would most likely add to the complexity of the research, however at the same time would also advance developments towards a more sustainable livestock production.

The findings of this dissertation demonstrate that improving AW by above-legal standards heavily depends on external incentives, i.e., price premiums for farmers. On the other hand, extra costs and thus price premiums are not extremely high for middle-market segments. These findings hold for an average farmer with an average farm performance due to the normative approach used in the study. However, differences in individual farm characteristics do exist. The models developed in this dissertation can be adapted to consider farm specific aspects in the future, e.g., by changing parameters of the model.

The demand for products with improved AW ultimately determines the extent of external incentives. Therefore, issues such as how to increase consumer long-term willingness-to-pay and the role of retail sector should be further studied.

On the basis of latest scientific findings, alternative production systems studied in this dissertation were assumed to provide a higher level of AW compared to the conventional system. However, the "real" improvement in AW experienced by the animal was not measured. Research can be further extended to study the "real" contribution of alternative production systems to the level of AW.

Land available for agricultural production is scarce, which is a main barrier in the adoption of alternative systems with free-range area. This especially holds for the study area (i.e., Noord-Brabant and Limburg), however is also an issue at country level. There are different ways to deal with this issue. For example, it is possible to increase free-range production through producing less animals per unit of land or outsourcing production beyond Dutch borders. An accurate assessment whether the option to outsource production is realistic is needed.

The Dutch market for animal-friendly products has proven to rapidly change over the last two decades. Legal requirements regarding AW were increased and several new market initiatives were introduced, which set AW standards higher than the minimum legal requirements (Oosterkamp et al., 2011). As a result, many farmers face a strategic choice of adopting higher AW standards. In the future, further developments are foreseen, which entail high level of uncertainty regarding their effect particularly on market dynamics, such as supply and demand for product with different levels of AW. Given the range of uncertainties inherent to farmers' decision to convert to an alternative system, the option to postpone the decision and wait for additional information has a value for the farmer (Pindyck, 1991). Research on farmers' decision-making related to AW can be further extended by valuing farmers' flexibility in decisions particularly related to irreversible investments. For this purpose, real option theory provides a suitable analytical tool (Dixit and Pindyck, 1994).

Conclusions

1. Financial incentives are more important determinants of adoption of additional above-legal animal welfare standards in the Dutch broiler and fattening pig farms than farmers' intrinsic motivation (*Chapter 2, 3, and 4*).
2. Dutch broiler and fattening pig farmers do not have a strong intrinsic motivation to switch to a production system that provides higher level of AW than the minimum legal requirements (*Chapter 3*).
3. Dutch broiler and fattening pig farmers are more willing to convert to an alternative system provided that the extra costs due to higher AW-standards are covered (*Chapter 4*).
4. Dutch broiler and fattening pig farmers are more willing to adopt systems requiring reversible investments than systems requiring irreversible investments (*Chapter 4*).
5. Farmers' decisions with regard to the implementation of higher AW standards predominantly depend on external conditions, such as price premium and farm-specific factors, such as current farm setup (*Chapter 4*).
6. Economic feasibility of improved AW-systems predominantly depends on the level and certainty of the price premium that farmers receive (*Chapter 5 and 7*).
7. In broiler production, health care costs represent only a small proportion of total production costs, regardless of the production system. Hence, the effect of animal health care costs on farmers' strategic decisions regarding the production system is small (*Chapter 6*).

8. In order to further develop the market for broiler products with higher levels of AW the main focus should be on increasing the certainty of price premiums (*Chapter 7*).
9. In order to increase the adoption of alternative fattening pig production systems, alternative systems have to be made financially more appealing to farmers by increasing price premiums (*Chapter 7*).
10. Alternative egg production systems are less economically feasible than the conventional egg production system (*Chapter 7*).

References

Babbie, E. (1990). Survey Research Methods. 2nd ed. Wadsworth Publishing Company, Belmont, California.

Baltussen, W., Bolhuis, J., De Bont, K., Van Horne, P., Hoste, R., van Leeuwen, M., Venema, G., Wisman, A. (2011). Perspectieven Brabantse intensieve veehouderijsector richting 2020 (in Dutch with english summary). LEI, Wageningen UR, The Hague, the Netherlands.

Baltussen, W.H.M., Hoste, R., van der Veen, H.B., Bokma, S., Bens, P., Zeewuster, H. (2010). Economische gevolgen van bestaande regelgeving voor de Nederlandse varkenshouderij, Rapport 2010-010. LEI, Wageningen UR, The Hague, the Netherlands.. Available at http://edepot.wur.nl/134934. Accessed 30-06-2014.

Banks, J. (1998). Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice. John Wiley and Sons, Inc., New York, USA.

Bokkers, E.A.M. (1997). Welzijnsproblematiek in de bedrijfsmatige vleeskuikenhouderij. Raad voor Dierenaangelegenheden, The Hague, the Netherlands.

Bornett, H.L.I., Guy, J.H., Cain, P.J. (2003). Impact of animal welfare on costs and viability of pig production in the UK. Journal of Agricultural and Environmental Ethics, 16:163-186. DOI: 10.1023/A:1022994131594.

Bos, J.M., Blok, V., van Tulder, R. (2013). From Confrontation to Partnerships: The Role of a Dutch Non-Governmental Organization in Co-Creating a Market to Address the Issue of Animal Welfare. International Food and Agribusiness Management Review, 16:69-75.

Brooshooft, S. (2014). Economic optimization of animal welfare in the Dutch broiler sector using the Welfare Quality® assessment protocol for poultry. MSc. Wageningen University, Wageningen.

De Buck, A.J., Van Rijn, I., Röling, N.G., Wossink, G.A.A. (2001). Farmers' reasons for changing or not changing to more sustainable practices: an exploratory study of arable farming in the Netherlands. The Journal of Agricultural Education and Extension, 7:153-166.

De Jonge, J., van Trijp, H.C.M. (2014). Heterogeneity in consumer perceptions of the animal friendliness of broiler production systems. Food Policy, 49:174-185. DOI: 10.1016/j.foodpol.2014.07.008.

De Young, R. (1996). Some psychological aspects of reduced consumption behavior - The role of intrinsic satisfaction and competence motivation. Environment and Behavior, 28:358-409. DOI: Doi 10.1177/0013916596283005.

Dijkhuizen, A.A., Morris, R.S. (1997). Animal health economics: principles and applications. Post Graduate Foundation in Veterinary Science, University of Sydney.

Dixit, A.K., Pindyck, R.S. (1994). Investment under uncertainty. Princeton University Press Princeton, New Jersey.

Dobson, P.W., Waterson, M., Davies, S.W. (2003). The Patterns and Implications of Increasing Concentration in European Food Retailing. Journal of Agricultural Economics, 54:111-125. DOI: 10.1111/j.1477-9552.2003.tb00053.x.

Edwards-Jones, G. (2006). Modelling farmer decision-making: concepts, progress and challenges. Animal Science, 82:783-790. DOI: 10.1017/Asc2006112.

Ellen, H., Leenstra, F., van Emous, R., Groenestein, K., van Harn, J., van Horne, P., De Jong, I., Kense, M., Mevius, D., Wagenaar, J.A. (2012). Vleeskuikenproductiesystemen in Nederland, Rapport 619 (in Dutch with English summary). Livestock Research, Wageningen University and Research Centre, Lelystad, the Netherlands.

EU. (2011). Study on the Competitiveness of the European Meat Processing Industry. European Commission, Luxembourg, Luxembourg. Available at http://ec.europa.eu/enterprise/sectors/food/files/report_compmeat_en.pdf. Accessed 14-07-2014.

Franz, A., von Meyer, M., Spiller, A. (2010). Prospects for a European animal welfare label from the german perspective: Supply chain barriers. International Journal of Food System Dynamics, 1:318-329.

Ghadim, A.K.A., Pannell, D.J., Burton, M.P. (2005). Risk, uncertainty, and learning in adoption of a crop innovation. Agricultural Economics, 33:1-9. DOI: DOI 10.1111/j.1574-0862.2005.00433.x.

Grabkowsky, B., Geenen, P., Windhorst, H.W., Saatkamp, H. (2007). Risk classification of Austrian, Dutch, and German poultry farms with regard to the incursion of the avian influenza virus. Commission of the European Communities, Brussels, Belgium.

Hamby, D.M. (1994). A review of techniques for parameter sensitivity analysis of environmental models. 32:135-154. DOI: 10.1007/bf00547132.

Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., Lien, G. (2004). Coping with risk in agriculture. 2nd ed. CABI, Wallingford.

Harvey, D., Hubbard, C. (2013). The Supply Chain's Role in Improving Animal Welfare. Animals, 3:767-785.

Hernon, P. (1994). Determination of Sample-Size and Selection of the Sample - Concepts, General Sources, and Software. College & Research Libraries, 55:171-179.

Hoste, R., Bondt, R., Ingenbleek, P. (2004). Visie op de varkenskolom, Rapport 207 (in Dutch with English summary). LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/19372, Accessed 10-07-2014.

Houwers, W., Leenstra, F., Lokhorst, K., Van Ruth, J., De Jong, I., Van den Top, M. (2004). Verkenningen voor een veerkrachtige pluimveeproductie. Rapport 308. Wageningen University and Reserach Center, Lelystad, the Netherlands. Available at http://www.archief.verantwoordeveehouderij.nl/producten/Pluimvleesproduktie/Verkenningen_PluimvleesProductie.pdf. Accessed 15-07-2014.

Immink, V.M., Reinders, M.J., van Tulder, R.J.M., van Trijp, J.C.M. (2013). The livestock sector and its stakeholders in the search to meet the animal welfare requirements of society. Journal on Chain and Network Science, 13:151-160. DOI: 10.3920/jcns2013.1005.

Ingenbleek, P., Harvey, D., Ilieski, V., Immink, V., de Roest, K., Schmid, O. (2013). The European Market for Animal-Friendly Products in a Societal Context. Animals, 3:808-829.

Janssen, S., van Ittersum, M.K. (2007). Assessing farm innovations and responses to policies: A review of bio-economic farm models. Agricultural Systems, 94:622-636.

Kerselaers, E., De Cock, L., Lauwers, L., Van Huylenbroeck, G. (2007). Modelling farm-level economic potential for conversion to organic farming. Agricultural Systems, 94:671-682. DOI: 10.1016/j.agsy.2007.02.007.

Kleijnen, J.P.C. (Year). Validation of models: statistical techniques and data availability. Proc. Proceedings of the Winter Simulation Conference, Phoenix, AZ, USA.

Kolk, A. (2005). Corporate Social Responsibility in the Coffee Sector:: The Dynamics of MNC Responses and Code Development. European Management Journal, 23:228-236. DOI: http://dx.doi.org/10.1016/j.emj.2005.02.003.

Law, A.M., Kelton, W.D. (1991). Simulation modeling and analysis. 2nd ed. McGrew-Hill Inc., New York.

Leinonen I., Williams, A.G., Wiseman, J., Guy, J., Kyriazakis, I. (2012). Predicting the environmental impacts of chicken systems in the United Kingdom through a life cycle assessment: Broiler production systems. Poultry Science, 91:8-25. DOI: 10.3382/ps.2011-01634.

Lusk, J.L. (2011). The market for animal welfare. Agriculture and Human Values, 28:561-575. DOI: 10.1007/s10460-011-9318-x.

Marra, M., Pannell, D.J., Ghadim, A.A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve? Agricultural Systems, 75:215-234. DOI: Pii S0308-521x(02)00066-5

Maurice, H., Van Horne, P.L.M., Horst, H.S. (1999). Welzijn versus economie binnen de kuikenvleesketen. Rapport 1.99.09. LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/45416. Accessed 11-07-2014.

McGlone, J.J. (2001). Farm animal welfare in the context of other society issues: toward sustainable systems. Livestock Production Science, 72:75-81. DOI: 10.1016/S0301-6226(01)00268-8.

McInerney, J.P., Howe, K.S., Schepers, J.A. (1992). A Framework for the Economic-Analysis of Disease in Farm Livestock. Preventive Veterinary Medicine, 13:137-154. DOI: 10.1016/0167-5877(92)90098-Z.

NOS. (2013). Fraude met Beter Leven-vlees. Available at http://nos.nl/artikel/547891-fraude-met-beter-levenvlees.html. Accessed 09-08-2014.

OECD. (2006). Supermarkets and the Meat Supply Chain: The economic impact of food retail on farmers, processors and consumers. Organisation for Economic Co-operation and Development, Paris, France. Available at http://www.oecd-ilibrary.org/docserver/download/5106111e.pdf?expires=1405337869&id=id&accname=oid006406&checksum=B50BEE61CDE866FD97EA0AC25742F6C2. Accessed 14-07-2014.

Ohlmer, B., Olson, K., Brehmer, B. (1998). Understanding farmers' decision making processes and improving managerial assistance. Agricultural Economics, 18:273-290.

Olsson, I.A.S., Gamborg, C., Sandoe, P. (2006) Taking ethics into account in farm animal breeding: What can the breeding companies achieve? Journal of Agricultural and Environmental Ethics, 19:37–46. DOI 10.1007/s10806-005-4494-6.

Oosterkamp, E., Van der Wielen, P., Vogelzang, T. (2013). Tussensegment voor varkens- en pluimveevlees: Een krachtveldanalyse in Duitsland en Europa (Intermediate segment for pork and poultry meat: A force field analysis in Germany and Europe) (in Dutch with English summary). LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/273691. Accessed 15-07-2014.

Oosterkamp, E.B., Bremmer, B., Hoste, R., De Greef, K.H. (2011). Verkenning van dierlijke tussensegment in onze buurlanden: Duurzam varkensvlees, pluimveevlees en eieren, LEI-rapport 2011-028 (in Dutch with English summary). LEI, Wageningen UR, The Hague, the Netherlands.

Padel, S. (2001). Conversion to organic farming: A typical example of the diffusion of an innovation? Sociologia Ruralis, 41:40-61.

Pannell, D.J. (1997). Sensitivity analysis of normative economic models: theoretical framework and practical strategies. Agricultural Economics, 16:139-152. DOI: 10.1016/S0169-5150(96)01217-0.

Pindyck, R.S. (1991). Irreversibility, Uncertainty, and Investment. Journal of Economic Literature, 29:1110-1148.

PVE. (2011). Statistics 2011 Livestock, meat and eggs. Product Boards for Livestock, Meat and Eggs, Zoetermeer, the Netherlands. Available at http://www.pve.nl/wdocs/dbedrijfsnet/up1/ZsxvvlzIkgB_431355PVVfolderENG__2_.pdf. Accessed 15-07-2014.

PVE. (2013). Livestock, Meat and Eggs in the Netherlands, Annual Survey 2012. Dutch Product Boards for Livestock Meat and Eggs, Zoetermeer, The Netherlands. Available at http://www.pve.nl/wdocs/dbedrijfsnet/up1/ZsxvvlzIqgB_432682PVEpromoENG_LR_definitief.pdf. Accessed 14-07-2014.

Schoon, B., te Grotenhuis, R. (2000). Values of farmers, sustainability and agricultural policy. Journal of Agricultural and Environmental Ethics, 12:17-27.

Shaw, S.A., Gibbs, J. (1995). Retailer-supplier relationships and the evolution of marketing: two food industry case studies. International Journal of Retail & Distribution Management, 23:7-16.

Te Velde, H., Aarts, N., Van Woerkum, C. (2002). Dealing with ambivalence: Farmers' and consumers' perceptions of animal welfare in livestock breeding. Journal of Agricultural & Environmental Ethics, 15:203-219.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S. (2002). Agricultural sustainability and intensive production practices. Nature, 418:671-677. DOI: 10.1038/Nature01014.

Valeeva, N.I. (2005). Cost-effectiveness of improving food safety in the dairy production chain. PhD. Wageningen University, Wageningen, the Netherlands.

Van Drunen, M., van Beukering, P., Aiking, H. (2010). The true price of meat. Institute of Environmental Studies, VU University, Amsterdam, the Netherlands. Available at http://www.ivm.vu.nl/en/Images/haW10-02aEN%20The%20true%20price%20of%20meat_tcm53-161385.pdf. Accessed 15-07-2014.

Van Horne, P.L.M. (2012). Competitiveness of the Dutch egg sector, Report 2012-079. LEI, Wageningen UR, The Hague, the Netherlands. Available at http://edepot.wur.nl/239093. Accessed 10-07-2014.

Vanhonacker, F., Verbeke, W. (2014). Public and Consumer Policies for Higher Welfare Food Products: Challenges and Opportunities. Journal of Agricultural and Environmental Ethics, 27:153-171. DOI: 10.1007/s10806-013-9479-2.

Veerman, D. (2014). "AH misleidt met Hollandse Kip" - en nu? Available at http://www.foodlog.nl/artikel/ah-misleidt-met-de-hollandse-kip-en-nu/. Accessed 16-08-2014.

Verspecht, A., Vanhonacker, F., Verbeke, W., Zoons, J., Van Huylenbroeck, G. (2011). Economic impact of decreasing stocking densities in broiler production in Belgium. Poultry Science, 90:1844-1851. DOI: 10.3382/ps.2010-01277.

Wakker Dier. (2014). Wakker Dier campaign to stop the sales of conventional broiler meat. Available at http://www.wakkerdier.nl/campagnes/plofkip-campagne. Accessed 09-08 2014.

Welfare_Quality®. (2009). Welfare Quality® assessment protocol for poultry (broilers, laying hens). Welfare Quality® Consortium, Lelystad, The Netherlands.

Willock, J., Deary, I.J., McGregor, M.M., Sutherland, A., Edwards-Jones, G., Morgan, O., Dent, B., Grieve, R., Gibson, G., Austin, E. (1999). Farmers' attitudes, objectives, behaviors, and personality traits: The Edinburgh Study of Decision Making on Farms. Journal of Vocational Behavior, 54:5-36.

Wilson, G.A., Hart, K. (2000). Financial imperative or conservation concern? EU farmers' motivations for participation in voluntary agri-environmental schemes. Environment and Planning A, 32:2161-2185. DOI: 10.1068/A3311.

Summary

Samenvatting

Acknowledgements

Curriculum vitae

Training and supervision plan

Summary

The intensification of livestock production has led to increasing public concerns regarding the welfare of animals particularly in poultry and pig production. Following these concerns, minimum legal standards regarding animal welfare (AW) have been introduced in the EU. Despite the legal standards, AW issues in intensive farming are still in the focus of societal debates in many EU countries, such as the Netherlands, Germany, and the UK. European citizens and consumers, particularly in North-Western Europe, demand further improvements in AW. Within the current international economic and political environment further improvements in the welfare of farm animals predominantly rely on market initiatives. In the Netherlands, conventional products have been criticized by society for the low levels of AW standards. As organic products are charged with a substantial price premium, only a small segment of consumers considers them as viable alternatives. Hence, a middle-market segment has emerged to supply alternative products that go beyond the minimum AW standards and are affordable for a larger public. Despite increasing criticism on the AW levels associated with conventional livestock products, the market share of the middle-market segment is still relatively small.

Middle-market initiatives set standards in terms of AW that exceed the legal minimum standards. Participation in a particular market initiative is a voluntary choice of the farmer. To date, most farmers are reluctant to implement new production systems and practices that provide more welfare to their animals. This reluctance can be a result of both objective factors, such as financial benefits and financial risk associated with a new production system, and subjective elements, such as farmers' perception of financial risk and farmers' moral and social goals. A knowledge gap pertains to farmer's subjective trade-offs between financial benefits, and risk considerations associated with the implementation of animal-friendly practices and systems and farmers' moral and social goals. Knowledge on these issues is essential to identify barriers to adoption of increased AW standards, which is needed to increase the supply that could potentially address the latent demand for AW products. Hence, the overall objective of this dissertation was to analyze the factors that determine farmers' decision-making with regard to the implementation of AW standards, to identify barriers to the adoption of above-legal AW standards at farm level, and to identify the potential means to mitigate these barriers.

Chapter 2 developed a theoretical framework for farmers' AW decisions and presented an approach to empirically implement the theoretical framework. Drawing on the literature in the fields of strategic decision making, technology, and innovation adoption, this chapter suggested that farmers' decisions related to AW standards depend on farmers multiple goals and

objectives. Financial and non-financial goals are hypothesized to affect farmers' AW decisions. In addition, decisions are constrained by a wide range of external and internal forces. This chapter suggested that for the analysis of a multi-objective problem, the multiple criteria decision making paradigm provides an appropriate theoretical framework. In addition, theories in social psychology, such as the Theory of Planned Behavior, were used to identify of relevant aspects in the decision making. The practical use of the conceptual framework was demonstrated using a simple numerical application of a multi-objective programming model. Two workshops were devoted to examining the scientific consistency and the practical usefulness of the approach.

Chapter 3 elicited Dutch broiler and fattening pig farmers' preferences about AW-related characteristics of production systems, with primary interest in farmers' intrinsic motivation towards AW. For this, conjoint analysis was used. Data were collected in the province of Noord-Brabant, which is the main production area of broiler and fattening pig in the Netherlands. Farmer-initiated study groups were approached to participate in the study. In total, 18 questionnaires from broiler farmers (out of 22) and 14 questionnaires from fattening pig farmers (out of 15) were usable for the conjoint analysis. The majority of both broiler and fattening pig farmers in our sample had medium-scale or large-scale farms and used a conventional production system. The main source of family income was the farm, which had been intensively expanded during the last five to ten years. In terms of their preferences, farmers preferred conventional practices over free-range systems. An expert panel confirmed that these findings hold for the majority of Dutch broiler and fattening pig farmers. A cluster analysis was carried out based on the estimated part-worths; two clusters of broiler farmers were identified. The 'Free-range focused' cluster evaluated a production system by focusing on a single aspect, the provision of free-range access, while the 'Multi-attribute focused' cluster took a more holistic view and included multiple attributes in their evaluation. Both clusters preferred the same levels per attribute, except for stocking density. However, the strength of preferences did differ between the two clusters. In the case of fattening pig farmers, no clusters were identified.

Chapter 4 investigated Dutch broiler and fattening pig farmers' willingness-to-convert to alternative production systems with higher AW standards compared to conventional production systems, and explored the main barriers to the adoption of these alternative systems. Data were collected from the same sample as in Chapter 3. The questionnaires of 15 broiler farmers (out of 22) and 13 fattening pig farmers (out of 15) were used for the analysis of willingness-to-convert. Results suggested that both broiler and fattening pig farmers are more willing to adopt systems requiring reversible changes in the farm than systems requiring irreversible changes. In addition, many farmers are willing to convert to a system requiring reversible changes if the increased costs due to higher AW standards are compensated. The study highlighted a number of reasons for farmers' reluctance to switch to alternative systems: perceived uncertainty about price premiums, lack of space on the farm, and scarcity of land available for agricultural production at regional and country level. A higher risk of disease spread in free-range broiler production systems was mentioned by many farmers as a potential barrier. In addition, the existing farm-setup sometimes limits the adoption of new systems. Farmers' reluctance appeared not to be caused by a negative attitude towards AW as such, but more related to the financial consequences of adopting alternative systems.

Chapter 5 analyzed the economic feasibility and risks of various AW standards on broiler farms over a five-year planning horizon. For this, a stochastic simulation model was developed using the @Risk add-in in MS Excel. The economic feasibility of different broiler production systems, represented by the cumulative capital debt repayment margin at the end of the 5th year, was compared. To compare the impact of different production systems in terms of economic feasibility, two cases were considered. The first case focused on the economic feasibility of a completely new system, whereas the second examined economic feasibilities when a farm switches from a conventional to an AW-improving production system. A sensitivity analysis was conducted to assess the key drivers of economic feasibility and to reveal systematic differences across production systems. This study showed that the economic feasibility of improved AW-systems predominantly depends on the prices that farmers receive, prices over which they have little control. Moreover, this study demonstrated the importance of accounting for both the level and the variation of the price premium, particularly during the first five years after adopting a new system. The economic feasibility of the production system increases with the level of welfare improvements for a sufficiently high price level for broiler meat and low volatility in producer prices. If this is not the case, risk attitudes of farmers become important as well as the use of potential risk management instruments.

Chapter 6 analyzed the effects of different broiler production systems on animal health care costs in the Netherlands. The study was limited to the most prevalent and economically relevant endemic diseases in the broiler farms. The model developed in Chapter 5 was adapted to calculate production and health care costs for each delivered broiler using partial budgeting approach in MS Excel. Health care costs were defined as the sum of losses and expenditures. Losses can be caused, for example, by mortality and reduced production efficiency, which results in reduced returns. Extra expenditures are mainly the costs of veterinary prophylactics

and therapeutic treatments to prevent or treat the disease. The study investigated whether higher AW standards increased health care costs, in both absolute and relative terms, and also examined which cost components (losses or expenditures) were affected and, if so, to what extent. The results showed that health care costs represent only a small proportion of total production costs in each production system. Losses account for the major part of health care costs, which makes it difficult to detect the actual effect of diseases on total health care costs. It was concluded that although differences in health care costs exist across production systems, health care costs only make a minor contribution to the total production costs relative to other costs, such as feed costs and purchase of one-day-old chicks. Therefore, the effect of health care costs on farmers' strategic decisions regarding the production system is most likely to be outweighed by other costs.

Chapter 7 compared the economic feasibility of alternative production systems with higher levels of AW for broiler, laying hen and fattening pig farms. In addition, the riskiness of implementing different production systems was analyzed, with particular emphasis on the degree of reversibility of the investment. In this chapter, the methodological approach developed in Chapter 5 was followed. The economic feasibility of different production systems was simulated over a five-year time horizon. Simulations were conducted using @Risk in MS Excel. Calculations for broiler production were made using the model developed in Chapter 5. Similar models were developed for laying hen and fattening pig production. The results strongly emphasized the importance of price premiums associated with AW concepts in all three sectors. From the perspective of the farm, different approaches should be followed in the three sectors to further develop the market for products with higher levels of AW. The results implied that the broiler sector has the best perspective in the short to medium term for developing this market. In the fattening pig sector, conversion options should be made more financially attractive, for example by increasing price premiums or providing conversion subsidies. The laying hen sector has the worst prospects for improving AW in the short to medium term. Therefore, given the current production systems in this sector, producer price premiums need to be increased in order to increase the adoption of alternative production systems.

In the General discussion (Chapter 8) the results were discussed in a wider context. The results implied that further development of the middle-market segment is a sensible direction in improving AW. This requires the involvement and commitment of all stakeholders in the supply chain, i.e., slaughterhouses, processors, retail, NGOs, and the government. Therefore, the role of different stakeholders was discussed. In addition, this concluding chapter reflected on the research approach and methods used in this dissertation and outlined directions for future

research. On the basis of the research chapters the following main conclusions are drawn:

1. Financial incentives are more important determinants of adoption of additional above-legal AW standards in the Dutch broiler and fattening pig farms than farmers' intrinsic motivation (*Chapter 2, 3, and 4*).
2. Dutch broiler and fattening pig farmers do not have a strong intrinsic motivation to switch to a production system that provides higher level of AW than the minimum legal requirements (*Chapter 3*).
3. Dutch broiler and fattening pig farmers are more willing to convert to an alternative system provided that the extra costs due to higher AW-standards are covered (*Chapter 4*).
4. Dutch broiler and fattening pig farmers are more willing to adopt systems requiring reversible investments than systems requiring irreversible investments (*Chapter 4*).
5. Farmers' decisions with regard to the implementation of higher AW standards predominantly depend on external conditions, such as price premium and farm-specific factors, such as current farm setup (*Chapter 4*).
6. Economic feasibility of improved AW-systems predominantly depends on the level and certainty of the price premium that farmers receive (*Chapter 5 and 7*).
7. In broiler production, health care costs represent only a small proportion of total production costs, regardless of the production system. Hence, the effect of animal health care costs on farmers' strategic decisions regarding the production system is small (*Chapter 6*).
8. In order to further develop the market for broiler products with higher levels of AW the main focus should be on increasing the certainty of price premiums (*Chapter 7*).
9. In order to increase the adoption of alternative fattening pig production systems, alternative systems have to be made financially more appealing to farmers by increasing price premiums (*Chapter 7*).
10. Alternative egg production systems are less economically feasible than the conventional egg production system (*Chapter 7*).

Samenvatting

De intensivering van de dierlijke productie in Nederland heeft in de afgelopen decennia geleid tot een toename van de zorg met betrekking tot dierenwelzijn (DW), in het bijzonder in de pluimvee- en varkensproductiesector. Als reactie hierop zijn in veel Europese landen de wettelijke vereisten voor het houden van dieren aangescherpt om zo het DW te verbeteren. Desondanks staat DW in veel landen nog vaak ter discussie in de samenleving. Vooral in Noordwest-Europese landen is er sprake van een toenemende vraag naar verbeteringen in de huisvesting ten gunste van het DW. In Nederland zijn in de afgelopen jaren zogenoemde tussensegment concepten ontwikkeld ten behoeve van DW. Deze concepten beogen een verbetering van het DW ten opzichte van conventionele systemen, die weliswaar voldoen aan de wettelijke vereisten, maar die niet zover gaan als organische concepten. Het doel van deze tussensegment concepten is om aan de latente vraag naar verbetering van DW, die bij de consumenten aanwezig is, te voldoen. Tot op heden is het marktaandeel van deze tussensegment concepten beperkt, met andere woorden: de latente consumentenvraag heeft zich nog maar beperkt vertaald in een verhoging van de daadwerkelijke vraag.

Het niveau met betrekking tot DW van de tussensegment concepten ligt hoger dan de wettelijke vereisten. Deelname is een vrijwillige keuze van de veehouder. Echter, tot op heden staan de meeste veehouders huiverig tegenover een dergelijke deelname en geven zij de voorkeur aan conventionele huisvestingssystemen. Deze aarzeling kan het gevolg zijn van zowel objectieve factoren (zoals financiële opbrengsten en risico's), als subjectieve factoren (zoals de perceptie van de veehouder ten opzichte van deze risico's, evenals zijn/haar ethische en sociale doelstellingen). Op dit moment is de kennis rondom de subjectieve afwegingen tussen deze aspecten, welke gericht zijn op een verbetering van het DW, beperkt. Deze kennis is echter essentieel om factoren te identificeren die van invloed kunnen zijn op het keuzegedrag van veehouders met betrekking tot DW. De globale doelstelling van deze dissertatie was daarom om de factoren te analyseren die bepalend zijn voor de besluitvorming van veehouders rondom de acceptatie van hogere DW normen, om mogelijke hindernissen te identificeren met betrekking tot deze acceptatie alsmede de mogelijkheden om deze hindernissen te verminderen.

In Hoofdstuk 2 wordt een conceptueel raamwerk beschreven welke is gericht op de besluitvorming van veehouders rondom DW, en waarbij evenals een manier wordt beschreven om dit raamwerk toe te passen in onderzoek. Op basis van wetenschappelijke literatuur op het gebied van strategische besluitvorming en nieuwe technologieën en innovaties beschrijft dit raamwerk de relatie tussen besluitvorming rondom huisvesting en DW enerzijds, en de diverse doelstellingen die een veehouder kan hebben anderzijds. De onderliggende hypothese is dat deze besluitvorming wordt beïnvloed door zowel financiële als non-financiële doelstellingen. Daarnaast kunnen allerlei interne en externe factoren een rol spelen. Het raamwerk in dit hoofdstuk toont aan dat voor de analyse van een probleem met een veelvoud aan doelstellingen, het multi-criteria decision making paradigma een goed theoretisch raamwerk biedt. Tevens zijn theorieën uit de sociale psychologie, zoals de Theory of Planned Behaviour, gebruikt om de relevante aspecten met betrekking tot besluitvorming te identificeren. Hoe dit conceptueel raamwerk praktisch gebruikt zou kunnen worden is beschreven met behulp van een toepassing van een simpel numeriek voorbeeld van het multi-criteria decision making model. Daarnaast zijn twee workshops gehouden om het raamwerk te toetsen op wetenschappelijke consistentie en praktische bruikbaarheid.

In Hoofdstuk 3 zijn de voorkeuren van vleeskuiken- en varkenshouders onderzocht met betrekking tot DW-gerelateerde kenmerken van productiesystemen, waarbij de intrinsieke motivatie van de veehouder met betrekking tot DW het belangrijkste aandachtsgebied was. Voor dit onderdeel is een conjoint analyse gebruikt. De data is verzameld bij veehouders afkomstig uit de provincie Noord-Brabant, wat geldt als het belangrijkste productiegebied voor vleeskuikens en –varkens in Nederland. Hiervoor zijn veehouders benaderd die lid waren van een studieclub. In totaal zijn 18 enquêtes van vleeskuikenhouders (op een totaal van 22) en 14 van vleesvarkenshouders (op een totaal van 15) bruikbaar bevonden voor het gebruik van de conjoint analyse. De meerderheid van de bruikbare respondenten had een gemiddeld tot groot bedrijf met een conventioneel productiesysteem. Binnen deze bedrijven was de veehouderij de belangrijkste bron van inkomen, en in de meeste gevallen was het bedrijf in de afgelopen vijf tot tien jaar uitgebreid. Een meerderheid van de respondenten had een voorkeur voor een conventioneel houderijsysteem boven een vrije uitloop. Deze uitkomst werd bevestigd door een panel bestaande uit experts afkomstig uit de veehouderij in de provincie Noord-Brabant. Tevens is een cluster-analyse uitgevoerd op basis van geschatte utiliteiten, die voor de vleeskuikenhouders resulteerde in de identificatie van twee clusters. De cluster 'vrije-uitloop gericht' beoordeelde productiesystemen op basis van één enkel aspect, namelijk de beschikbaarheid van vrije uitloop, terwijl de cluster 'verschillende kenmerken gericht' een meer holistische kijk had, wat gepaard ging met het betrekken van meerdere kenmerken in hun evaluatie. Beide clusters hadden een voorkeur voor dezelfde niveaus per attribuut, met uitzondering van dierdichtheid. Echter, de sterkte van de voorkeuren tussen beide clusters was verschillend. Bij de vleesvarkenshouders was er geen sprake van clustering.

In Hoofdstuk 4 wordt ingegaan op de bereidheid van vleeskuiken- en varkenshouders om over te schakelen op alternatieve productiesystemen met hogere DW normen in vergelijking met de conventionele systemen (‘willingness-to-convert’); tevens werden de belangrijkste hindernissen voor een dergelijke verandering geïdentificeerd. De response van 15 vleeskuikenhouders (op een totaal van 22) en van 13 vleesvarkenshouders (op een totaal van 15) was bruikbaar voor deze ‘willingness-to-convert’ analyse. De resultaten tonen dat zowel vleeskuiken- als varkenshouders een grotere bereidheid hadden om over te stappen naar systemen waarbij reversibele investeringen mogelijk zijn. Daarnaast kwam naar voren dat de bereidheid tot omschakelen vergroot kan worden indien deze verandering gepaard gaat met een verhoging van de opbrengstprijs. Tevens kwamen in dit hoofdstuk een aantal redenen naar voren die betrekking hebben op de aarzeling voor verandering bij veel veehouders. Dit betreft redenen als: de onzekerheid van prijspremiums, het ruimtegebrek rondom het bedrijf, en het gebrek aan ruimte voor ontwikkeling van de veehouderijproductie op regionaal en landelijk niveau. Daarnaast speelt het risico op ziekten bij vrije uitloop systemen. Hierbij is van belang dat de bestaande bedrijfsopzet vaak al beperkend is voor een verdere uitbreiding of bedrijfsontwikkeling. Echter, de aarzeling bij veel veehouders kwam niet voort uit een negatieve grondhouding ten opzichte van DW als zodanig, maar meer uit een vrees voor de financiële risico’s die met alternatieve huisvestingssystemen gepaard gaan.

Hoofdstuk 5 behandelt de economische haalbaarheid en risico’s van een aantal DW concepten voor vleeskuikens over een tijdshorizon van 5 jaar. Hiervoor is een stochastisch simulatiemodel ontwikkeld in MS Excel en @Risk. De cumulatieve terugbetalingscapaciteit aan het einde van de 5-jarige tijdshorizon werd als maatstaf genomen voor de economische haalbaarheid. Hierbij werden 2 situaties onderscheiden, te weten een compleet nieuwe bedrijf, en een situatie waarin een bestaand conventioneel bedrijf overschakelt naar een alternatief, meer DW-vriendelijk concept. Voor dit onderdeel is ook een uitgebreide gevoeligheidsanalyse uitgevoerd om het effect van belangrijke factoren nader te analyseren. Aangetoond is dat vooral de prijs-premium bepalend was voor de economische haalbaarheid. De veehouder kan hier echter nagenoeg geen invloed op uitoefenen. Tevens werd het belang getoond van zowel de hoogte van de prijs-premium als de variatie gedurende de eerste 5 jaar. De economische haalbaarheid van DW-vriendelijke productiesystemen nam toe met het niveau van de welzijnsverbeteringen indien de prijs-premium toenam, alsmede wanneer de volatiliteit afnam. Als van beide effecten geen sprake is, worden de risico-houding van de veehouder en mogelijke andere risk-management instrumenten op het bedrijf bepalende factoren.

In Hoofdstuk 6 wordt ingegaan op de relatie tussen het huisvestingssysteem voor vleeskuikens en de kosten voor de diergezondheid. Dit onderdeel beperkte zich tot de meest belangrijke endemische pluimveeziekten die voorkomen in Nederland. Het simulatiemodel dat in Hoofdstuk 5 werd ontwikkeld is aangepast voor bovengenoemde doelstelling, waarbij een partial budgeting methode is gebruikt om de verschillende systemen en ziekten met elkaar te kunnen vergelijken. De kosten voor diergezondheid zijn gedefinieerd als de som van schade en uitgaven als gevolg van dierziekten. Schade kan bijvoorbeeld worden veroorzaakt door een verhoogde sterfte of een verminderde productie efficiëntie, wat tot verminderde netto-opbrengsten kan leiden. Uitgaven kunnen worden veroorzaakt door verhoogde kosten voor curatieve en therapeutische behandeling. Het doel was om na te gaan of productiesystemen met een verhoogd DW te maken krijgen met verhoogde gezondheidskosten (zowel absoluut als relatief), en welke categorie hiervoor verantwoordelijk is (schade of uitgaven). Uit deze studie kwam naar voren dat gezondheidskosten slechts een relatief klein deel van de totale productiekosten zijn, ongeacht het productiesysteem. Van de totale gezondheidskosten komt het grootste deel voor de rekening van de schade wat een verdere toerekening aan de directe ziekte-effecten bemoeilijkt. Geconcludeerd is dat, ofschoon de verschillende productiesystemen verschillende gezondheidskosten hadden, de bijdrage aan de totale kosten vrij beperkt was in vergelijking met bijvoorbeeld de kosten voor de eendagskuikens en voer. Met andere woorden: het effect van verandering van gezondheidskosten bij overschakeling naar een ander productiesysteem speelt bij de keuzeproblematiek een ondergeschikte rol.

In Hoofdstuk 7 werd de economische haalbaarheid van verschillende productiesystemen voor zowel vleeskuikens, leghennen als vleesvarkens onderling vergeleken. Hierbij zijn tevens de risico-aspecten meegenomen, in het bijzonder de mogelijkheid van ‘reversibility’. In dit onderdeel werd dezelfde model-aanpak gebruikt zoals beschreven in Hoofdstuk 5, inclusief de tijdshorizon van 5 jaar. Waar nodig werd het model voor vleeskuikens aangepast aan de situaties van leghennen en vleesvarkens. De resultaten toonden opnieuw, nu voor alle drie sectoren, het belang van de prijs-premium. Er kwamen echter ook verschillen tussen de drie sectoren naar voren, voornamelijk wat betreft het perspectief voor marktontwikkeling op de korte en middellange termijn. De perspectieven voor vleeskuikens blijken het meest aantrekkelijk te zijn: in principe zorgen de prijs-premiums voor voldoende rendement. Bij vleesvarkens is er sprake van beperkt verschil in economische haalbaarheid, en dienen conversie alternatieven over de gehele linie financieel aantrekkelijker te worden gemaakt, bijvoorbeeld door middel van verhoging van de prijs-premiums en/of subsidie. Voor de leghensector zijn de huidige perspectieven het meest beperkt: alleen een aanzienlijke verbetering van de prijs-premium voor systemen met een verhoogd DW kan dit systeem aantrekkelijk maken voor veehouders.

In de General Discussion in Hoofdstuk 8 worden de resultaten in een bredere context geplaatst. Een belangrijke overall conclusie is dat een verdere ontwikkeling van de tussensegmenten een belangrijke stap is voor de verbetering van het DW. Een dergelijke ontwikkeling vereist de betrokkenheid van alle stakeholders in de productieketen, voornamelijk van veehouders, slachthuizen, verwerkende bedrijven, retail, NGO's en de overheid. Daarnaast is de rol van de verschillende stakeholders verder besproken. Daarnaast zijn in dit afsluitende hoofdstuk de gebruikte onderzoeksaanpak en methoden gereflecteerd, en is de mogelijke richting van toekomstig onderzoek bepaald. Op basis van de bovengenoemde hoofdstukken kunnen de volgende conclusies worden getrokken:

1. Voor een overgang naar productiesystemen met een verhoogd DW zijn financiële stimulansen belangrijker dan de intrinsieke motivaties van de vleeskuiken- en -varkenshouders *(Hoofdstukken 2, 3 en 4)*.
2. De Nederlandse vleeskuiken- en –varkenshouders hebben over het algemeen geen sterke intrinsieke motivatie om over te schakelen van de wettelijke vereiste conventionele systemen naar alternatieve productiesystemen met een hoger DW (*Hoofdstuk 3)*.
3. De Nederlandse vleeskuiken- en –varkenshouders zijn bereid om over te schakelen naar alternatieve productiesystemen wanneer de extra kosten die hiermee gepaard gaan zullen worden gedekt *(Hoofdstuk 4)*.
4. De Nederlandse vleeskuiken- en –varkenshouders hebben, in geval van omschakeling, een voorkeur voor reversibele veranderingen boven irreversibele investeringen (*Hoofdstuk 4)*.
5. De besluitvorming van veehouders rondom systemen met een hoger DW wordt voornamelijk bepaald door externe factoren, zoals de prijs-premium, en bedrijfsspecifieke factoren, zoals de huidige bedrijfsopzet *(Hoofdstuk 4)*.
6. De economische haalbaarheid van productiesystemen met een verhoogd DW hangt voornamelijk af van het niveau van de prijs-premium en de zekerheid hiervan *(Hoofdstukken 5 en 7)*.
7. In de vleeskuikenhouderij vormen gezondheidskosten maar een klein deel van de totale productiekosten, ongeacht het productiesysteem. Daarom is het effect van verandering van deze kosten op de besluitvorming rondom het productiesysteem gering *(Hoofdstuk 6)*.
8. Om de markt voor vleeskuiken producten verder te ontwikkelen moet voornamelijk aandacht worden besteed aan het vergroten van de zekerheid van de prijs-premium *(Hoofdstuk 7)*.

9. Om de bereidheid van varkenshouders om over te stappen naar meer DW-vriendelijke productiesystemen te verhogen moeten deze systemen financieel aantrekkelijker worden gemaakt doormiddel van een verhoging van de prijs-premium *(Hoofdstuk 7)*.
10. De economische haalbaarheid van alternatieve systemen voor leghennen ligt lager in vergelijking met die van conventionele systemen *(Hoofdstuk 7)*.

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Curriculum vitae

Éva Gocsik was born on September 13, 1985 in Debrecen, Hungary. In 2004, she entered the University of Debrecen (Hungary) to study agricultural economics. In 2008, she obtained a scholarship to join the Double Degree program between the University of Debrecen and Wageningen University. She specialized in business economics at Wageningen University. She wrote her master thesis on the subject of potential impact of recent EU legislation on commodity and biofuel trade flows, at the Rabobank International in Utrecht. In 2010, she graduated with the degree of MSc from the University of Debrecen and from the degree of MSc from Wageningen University. In 2010, Eva started her PhD research at the Business Economics Group of Wageningen Univesity. Her PhD project was part of larger research program titled 'The Value of Animal Welfare' funded by the Netherlands Organisation for Scientific Research (NWO) and the Dutch Ministry of Economic Affairs. During her PhD, Eva completed her education program, presented her work in international conferences, published in international peer-reviewed journals, and collaborated with a group of farmers, policy-makers and agri-sector representatives. She spent two months at Swedish University of Agricultural Sciences in Uppsala (Sweden) as visiting researcher. From July 2014 Eva continues to work at the Business Economics Group as a post-doc.

Éva Gocsik

Wageningen School of Social Sciences (WASS)

Completed Training and Supervision Plan

DESCRIPTION	INSTITUTION[1]	YEAR	ECTS[2]
General courses			
Introduction course	WASS	2012	1.5
Writing PhD research proposal	WUR	2010	4
Discipline-specific courses			
Summer School: Theory and Practice of Efficiency and Productivity Measurement	WASS	2010	3
Advanced Microeconomics (ECH 32306)	WUR	2010	6
Multivariate Data Analysis	NAKE	2011	3
Decision Science II. (ORL30306)	WUR	2011	6
Quantitative Data Analysis: Multivariate Techniques (YRM 60306)	WUR	2011	6
PhD course "Waardering van Dierenwelzijn"	NWO	2010-2013	3
Scientific Research in Animal Welfare: Do We Make a Difference?	WIAS	2011	0.15
Business Economics PhD meetings	BEC/WUR	2010-2014	4
Career related competences/ personal development			
Voice matters – Voice and Presentation Skills Training	BEC/WUR	2011	0.5
Presentation Skills	Language Services, WUR	2011	1
Techniques for Writing and Presenting Scientific papers	Language Services, WUR	2011	1.2
Dutch Speaking and Listening III.	Language Services, WUR	2012	2.4
Teaching and supervising activities			
Computer labs: Corporate Financial Management	BEC/WUR	2010-2013	2
Computer labs: Food Safety Economics	BEC/WUR	2011-2013	0.5
Computer labs: Financial Business Management	BEC/WUR	2012-2013	0.5
Supervising MSc Students	BEC/WUR	2013-2014	1
Conference presentations			
'Conceptual approach for the quantitative economic analysis of farmers' decision making on animal welfare'	Symposium 'The value of animal welfare', Utrecht, the Netherlands	2011	1

‘A conceptual approach for analysis of farmers’ animal welfare decisions’	Minding Animals Conference, Utrecht, the Netherlands	2012	1
‘Bio-economic simulation modeling to analyze on-farm animal welfare decisions’	IWFAHE, Aarhus University, Foulum, Denmark	2012	1
‘Impact of improved animal welfare on health costs in Dutch broiler production’	25th Annual VEEC Meeting, Bilthoven, the Netherlands	2013	1
‘Financial impact of animal welfare improvements in Dutch broiler production’	IFAMA Scientific Research Symposium, Cape Town, South Africa	2014	1
Total			**50.75**

[1] WASS = Wageningen School of Social Sciences, ECH = Economics of Consumers and Households Group, WUR = Wageningen University and Research Center, BEC = Business Economics Group, NAKE = Netherlands Network of Economics, ORL = Operations Research and Logistics Group, YRM = Research Methodology Group, NWO = The Netherlands Organisation for Scientific Research, WIAS = Wageningen Institute of Animal Sciences, IWFAHE = International Workshop on Farm Animal Health Economics, VEEC = Dutch Society for Veterinary Epidemiology and Economics, IFAMA = International Food and Agribusiness Management Association

[2] One credit according to ECTS is on average equivalent to 28 hours of study load

Colophon

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