PIG HUSBANDRY IN A CHANGING SOCIAL AND ECONOMIC ENVIRONMENT

Societal attitudes, farm economics and animal welfare

Tamara J. Bergstra

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Thesis

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Abstract

The Dutch pig sector is attempting to address citizens' concerns about animal welfare practices. Measures to improve animal welfare that were introduced by the pig sector did, however, not have the desired effect on citizens' attitudes toward pig husbandry. This indicates that an improvement of animal welfare does not necessarily result in an improvement of citizens' attitudes. This thesis aimed to estimate the effects of measures to improve animal welfare in sow husbandry in the Netherlands on animal welfare, farm income and citizens' attitudes. First, the attitudes of citizens and other stakeholders of sow husbandry, i.e., pig farmers (conventional and organic), pig husbandry advisors and pig veterinarians, were investigated using a survey. It was shown that the large majority of respondents of citizens have negative attitudes toward sow husbandry with respect to aspects related to animals, humans and the environment. Citizens differed in these attitudes from the other stakeholders, except organic pig farmers. Based on their attitudes, citizens could be divided into four separate clusters. These clusters differed in terms of their attitudes toward sow husbandry and in their socio-demographic features.

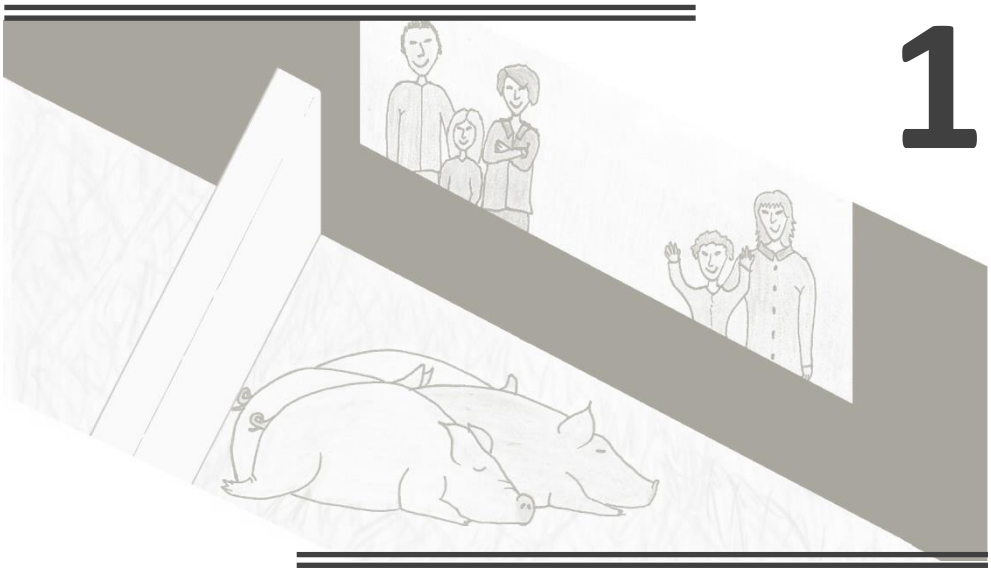
Basic values underlie attitudes, but this thesis showed that basic values related to sow husbandry are not one-on-one related to attitudes toward sow husbandry of citizens and conventional pig farmers. Between conventional pig farmers and clusters of citizens there were differences in basic values related to sow husbandry. The two clusters with the most negative attitudes toward sow husbandry did not agree on the valuation of basic values with conventional pig farmers, while the other two clusters did on most of the basic values. The biggest cluster of the latter two clusters did also agree on the valuation of several basic values with the two clusters that did not agree with conventional pig farmers. This cluster can be useful for pig farmers to learn to understand the interpretation and weighing of basic values by citizens. An understanding that can be used in the development of new systems and measures to improve animal welfare within sow husbandry and in the communication between the pig sector and citizens.

Furthermore, in this thesis a simulation model was developed in which the effects of different measures for sow husbandry on animal welfare and farm income can be estimated. For each of the defined issues of sow husbandry, i.e., piglet mortality, tail biting and indoor housing, four measures were defined to improve animal welfare in an existing reference sow farm, representative for the Netherlands. The measures that aimed to reduce piglet mortality were the only measures with a positive effect on farm income. These measures had the best cost-effectiveness ratio compared to the other defined measures. When extending the simulation model with estimating the effects on citizens'

attitudes, the measure that includes straw provision, daylight and increased group sizes of gestating sows was the most efficient compared to the other defined measures. Results show that a positive effect of a measure on animal welfare does not necessarily lead to a similar relative improvement of citizens' attitudes or a deterioration of farm income.

This thesis has shown that in order to achieve an improvement of citizens' attitudes, it is essential for the pig sector to evaluate animal welfare measures using an approach that integrates the effects of measures on animal welfare, farm income and citizens' attitudes.

Contents



1

General introduction

1.1 Background

After World War II, animal husbandry changed drastically as a result of changing policies that aimed for sufficient meat production (Fraser et al., 2001; Rollin, 2004). A sufficient meat production meant that plentiful meat of good quality had to be produced for low prices (Fraser et al., 2001; Rollin, 2004). To meet these requirements, farmers were stimulated to strive for productivity and efficiency (Fraser et al., 2001; Rollin, 2004). This is when intensive animal husbandry arose in which animals were confined and automation for routine tasks increased to replace human labor (Fraser et al., 2001). As a result, the number of farms decreased and the number of animals per farm increased (Bock and van Huik, 2007; Fraser et al., 2001; Fraser, 2003; Rollin, 2004). In addition, the production per animal increased rapidly because of improved breeding, feeding and husbandry systems (Fraser et al., 2001). The increasing efficiency and the possibility to sell products in larger markets, because of innovations in product preservation and improvements in transport, resulted in increasing price competition (Fraser et al., 2001). To be able to take part in this competition, farmers were forced to produce against lower costs (Fraser et al., 2001; Van der Meulen et al., 2011). A way to increase efficiency and lower production costs was specialization, where farmers specialize and focus on one type of animal husbandry system, such as breeding pigs or finishing pigs (Meerburg et al., 2009; Roe et al., 2002). The number of pig farms in the Netherlands have been decreasing rapidly in the last decades (Figure 1.1) while the total number of pigs stayed approximately at the same level (Van der Meulen et al., 2011).

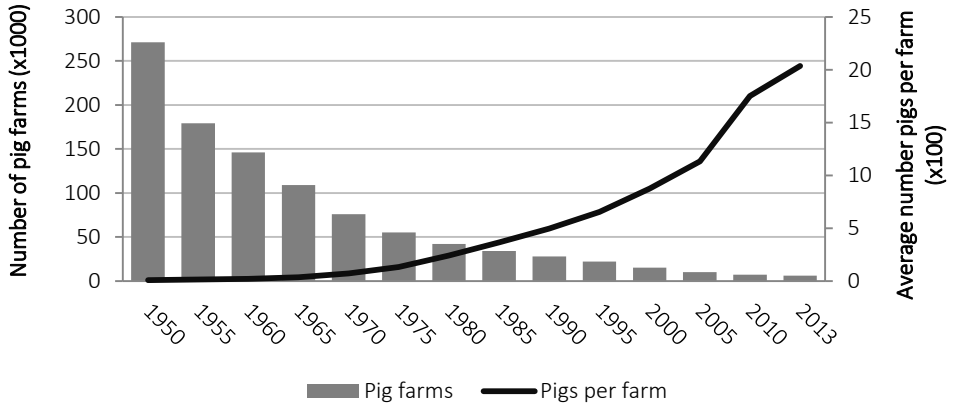


Figure 1.1 The number of farms with pigs (breeding and/or finishing) and the number of pigs per farm in the Netherlands from 1950 until 2013.
Source: Centraal Bureau voor de Statistiek, 2013

A changing social and economic environment

Before the start of intensification of animal husbandry, around 50% of the people in western societies were involved in animal production, while currently this is around 1.5% (Rollin, 2004). Moreover, specialization led to lower societal involvement because open farming systems changed into closed system where animals stay inside farms that are not accessible to citizens (Van der Meulen et al., 2011). Being less involved in animal production has also made the majority of citizens less familiar with animal production (Marchant-Forde, 2009; Meerburg et al., 2009). Consequently, the public no longer received first-hand information and had to base their judgments about animal husbandry on information presented by interest groups and the media (Beekman et al., 2002; Harper and Henson, 2001). As a result, the distance between citizens and animal husbandry increased, which led to a change in the relationship between citizens and animal husbandry.

The relationship between farmers and their animals also changed because of intensification. Traditional animal husbandry focused on the individual animal, while intensive animal husbandry no longer pays attention to the individual animal but focuses on the total production of all animals (Rollin, 2004). This resulted in a change of animal handling and, consequently, in a change of animal welfare (Rollin, 1994; Rollin, 2004). As a result, the ethical view of people considering animals changed (Rollin, 1994). Also societal development, such as higher education and higher income (Boudon, 1974), contributed to changing ethical views related to animals, humans and the environment (Apotheker, 2000). These changing ethical views made citizens more and more aware of the possible conflict between animal husbandry and moral values with regard to animal well-being, autonomy and justice (Mepham, 2000). Because moral values are the basis of attitudes (Rokeach, 1968-1969), citizens' attitudes toward animal husbandry changed after the change in ethics (Chrispeels and Mandoli, 2003).

Besides moral values and attitudes toward animal husbandry, it is essential for farmers to take their market position into account. To keep their market position, in the last decades the focus of animal husbandry was mainly on keeping production costs low (Apotheker, 2000; Fraser et al., 2001). However, currently, in order to keep a good market position and get citizens' support, farmers have to anticipate on two factors; changing attitudes and changing costs (Apotheker, 2000).

1.2 Problem statement

Negative citizens' attitudes toward animal husbandry can lead to citizens' concerns about animal husbandry. These concerns have increased since intensification which resulted in an increasing number of public debates regarding animal welfare in intensive animal husbandry systems (Beekman et al., 2002; Norwood and Lusk, 2009). For farmers it is important to respond to these concerns in order to keep their license to produce (Backus and van der Schans, 2000), which means that society accepts that their way of animal husbandry exists (Mureau, 2000). In the Netherlands, one of the animal husbandry systems that tries to keep their license to produce is sow husbandry. In order to keep this license, sow husbandry responded to citizens' concerns by introducing new measures to improve animal welfare. These measures often focus on a single issue of concern and focus on the measurable results of the measures (Beekman et al., 2002). For example, for the issue 'piglet mortality', the focus is just on decreasing piglet mortality and therefore the measure 'motherless rearing' is introduced (Huysman et al., 1994). Despite that the introduced measure aims for the improvement of animal welfare by decreasing piglet mortality, citizens' concerns about sow husbandry remain (Aarts et al., 2001; De Greef et al., 2006; Meuwissen and van der Lans, 2005). These remaining concerns indicate that measures on animal welfare do not have the desired effects on citizens' attitudes. To understand why animal welfare measures fail in improving citizens' attitudes it is essential to identify the effects of these measures on citizens' attitudes, next to their effects on animal welfare.

Before it is possible to identify the effects of measures to improve animal welfare in sow husbandry on citizens' attitudes it is essential to determine these attitudes. In determining these attitudes, the focus should be on different aspects related to entities, i.e., animals, humans and the environment, that play a role in sow husbandry. Attitudes related to these aspects are considered in concerns about sow husbandry (Beekman et al., 2002; Blokhuis et al., 2003; Harper and Henson, 2001; Mepham, 2000). For example, the public showed negative attitudes toward pig housing (e.g., the limited space per animal and the lack of outdoor access; Boogaard et al., 2011; Meuwissen and van der Lans, 2005; Verbeke and viaene, 2000), animal transport (Meuwissen and van der Lans, 2005), piglet castration (Frederiksen et al., 2010; Huber-Eicher and Spring, 2008; Lagerkvist et al., 2006), the potential effects of antibiotic use in pigs on human health (Ngapo et al., 2003) and the

effects of sow husbandry waste on the environment (Kanis et al., 2003; Marchant-Forde, 2009; Ngapo et al., 2003). In order to know which aspects play a role in citizens' concerns about sow husbandry, the attitudes toward sow husbandry in respect to these different aspects have to be studied. Several studies have been carried out on attitudes toward pig husbandry in general (Boogaard et al., 2011; Frederiksen et al., 2010; Krystallis et al., 2009; Lagerkvist et al., 2006; Meuwissen and van der Lans, 2005; Ngapo et al., 2003; Petit and van der Werf, 2003). However, none of these studies included aspects related to all three entities.

Previous studies have shown that attitudes are influenced by socio-demographic features, such as age and gender (Harper and Henson, 2001; Knight et al., 2004; Vanhonacker et al., 2010). It is necessary to study if groups of citizens with different socio-demographic features have different attitudes toward sow husbandry in order to know whether different citizens should be approached differently with the introduction of a measure to improve animal welfare in sow husbandry.

It is known that attitudes toward sow husbandry differ between stakeholders that play a role in decision making for sow husbandry, e.g., citizens, pig farmers and pig husbandry advisors (Lassen et al., 2006; Petit and van der Werf, 2003; Van Huik and Bock, 2007). These different attitudes can cause friction between stakeholders. To understand where there is friction between stakeholders, it is essential to study their attitudes toward sow husbandry in respect to aspects related to the three entities.

The differences between stakeholders in attitudes toward sow husbandry may be caused by different interests. For example, pig farmers have an interest in the economic consequences for their business of an animal welfare measure (Bracke et al., 2005; Te Velde et al., 2002) and the public shows primarily an interest in animal welfare (Te Velde et al., 2002). These different interests make that pig farmers implement measures that are economically viable (De Greef and Casabianca, 2009), while the public wants animals to live happy lives that meet their natural standards as much as possible (Rollin, 2004). Some of these natural standards have been regulated by law. For example, to allow pigs to express social behavior it is no longer allowed to house pigs individually in the Netherlands. Although sow farmers adhere to the requirements set by law and want to take good care of their animals for a good animal welfare, citizens are not convinced that how sow farmers treat their animals is the way to take good care of animals (Beekman et al., 2002). In

deciding what 'taking good care of animals' means, moral values play an important role. As the weighing of moral values also differs between stakeholders (Cohen et al., 2010a, 2010b) it is interesting to study whether moral values can explain the different attitudes toward sow husbandry between stakeholders. The moral values that are important for attitudes toward sow husbandry can be added to the theoretical framework that includes aspects that play a role in attitudes toward sow husbandry. Such a framework can help defining moral values that are relevant for the aspects that are important in attitudes toward sow husbandry.

Including both animal welfare and public attitudes, and the importance of economic sustainability for pig farmers means that for successfulness of measures to improve animal welfare in sow husbandry, different disciplines, i.e., animal science, social science and economics, have to be addressed. Therefore, an interdisciplinary approach is essential to determine the total effect of these measures. Interdisciplinary approaches that included two of these disciplines, e.g., animal science and economics, have been used before (Bruijnis et al., 2013; Cain and Guy, 2006; Gocsik et al., 2013; Stott et al., 2012; Vosough Ahmadi et al., 2011). However, an interdisciplinary approach that integrates all three disciplines has not been used before.

1.3 Objectives

The main objective of this thesis was to estimate the effects of measures to improve animal welfare in sow husbandry in the Netherlands on animal welfare, farm income and citizens' attitudes. Sow husbandry was the husbandry system under study because the issues related to pig husbandry that were presented in the Dutch media from 2009 until 2011 (e.g., piglet mortality, piglet castration and weaning age of piglets) mainly focused on sow husbandry (Stichting Varkens in Nood, 2010; Wakker dier, 2010).

The main objective was achieved through five sub objectives:

1. Determine attitudes of Dutch citizens toward relevant aspects related to animals, humans and the environment with regard to sow husbandry, to group citizens based on these attitudes and to determine and compare socio-demographic features of these groups.
2. Determine and compare attitudes toward relevant aspects related to animals, humans and the environment with regard to sow husbandry of various stakeholders, i.e., citizens, pig farmers (organic and conventional), pig husbandry advisors and pig

veterinarians, and to determine and compare the acceptability of issues related to sow husbandry, such as piglet mortality and castration, of the various stakeholders.

3. Determine and compare moral values toward sow husbandry of (groups of) citizens and conventional pig farmers, and to find out how basic values can be useful in closing the gap between attitudes toward sow husbandry of these groups.
4. Estimate and compare the effects of different measures to improve animal welfare in sow husbandry on animal welfare and farm income.
5. Identify the effects of different measures to improve animal welfare in sow husbandry on citizens' attitudes, next to their effects on animal welfare and farm income, and compare these measures in their overall efficiency.

1.4 Outline

This thesis is divided into seven chapters, including the current chapter (Figure 1.2). Chapter 2 through 6 are research chapters that elaborate on the aforementioned sub objectives. The last chapter contains the general discussion.

Chapter 2 describes a theoretical framework that includes aspects related to entities of sow husbandry, i.e., animals, humans and the environment, that are important in attitudes toward sow husbandry. This framework forms the basis for the remainder of this thesis. Based on this framework, the attitudes of Dutch citizens toward aspects of sow husbandry will be studied in Chapter 2. Cluster analysis will be used to test whether these citizens can be divided in different groups based on their attitudes toward sow husbandry. The different groups will be compared in their socio-demographic features.

Chapter 3 determines the attitudes toward the aspects from the framework described in Chapter 2 of conventional pig farmers, organic pig farmers, pig veterinarians and pig husbandry advisors. To compare the attitudes of these stakeholders and citizens, data on attitudes of citizens' toward sow husbandry generated in Chapter 2 are used in Chapter 3. Furthermore, Chapter 3 studies what stakeholders find acceptable with regard to issues of sow husbandry, such as piglet mortality, castration and indoor housing.

Chapter 4 supplements the theoretical framework described in Chapter 2 with moral values that are important for attitudes toward sow husbandry. The moral values of citizens and conventional pig farmers will be determined and the moral values of the groups of citizens determined in Chapter 2 and conventional pig farmers will be compared. Based on these results and the results on attitudes of citizens and conventional pig farmers toward sow

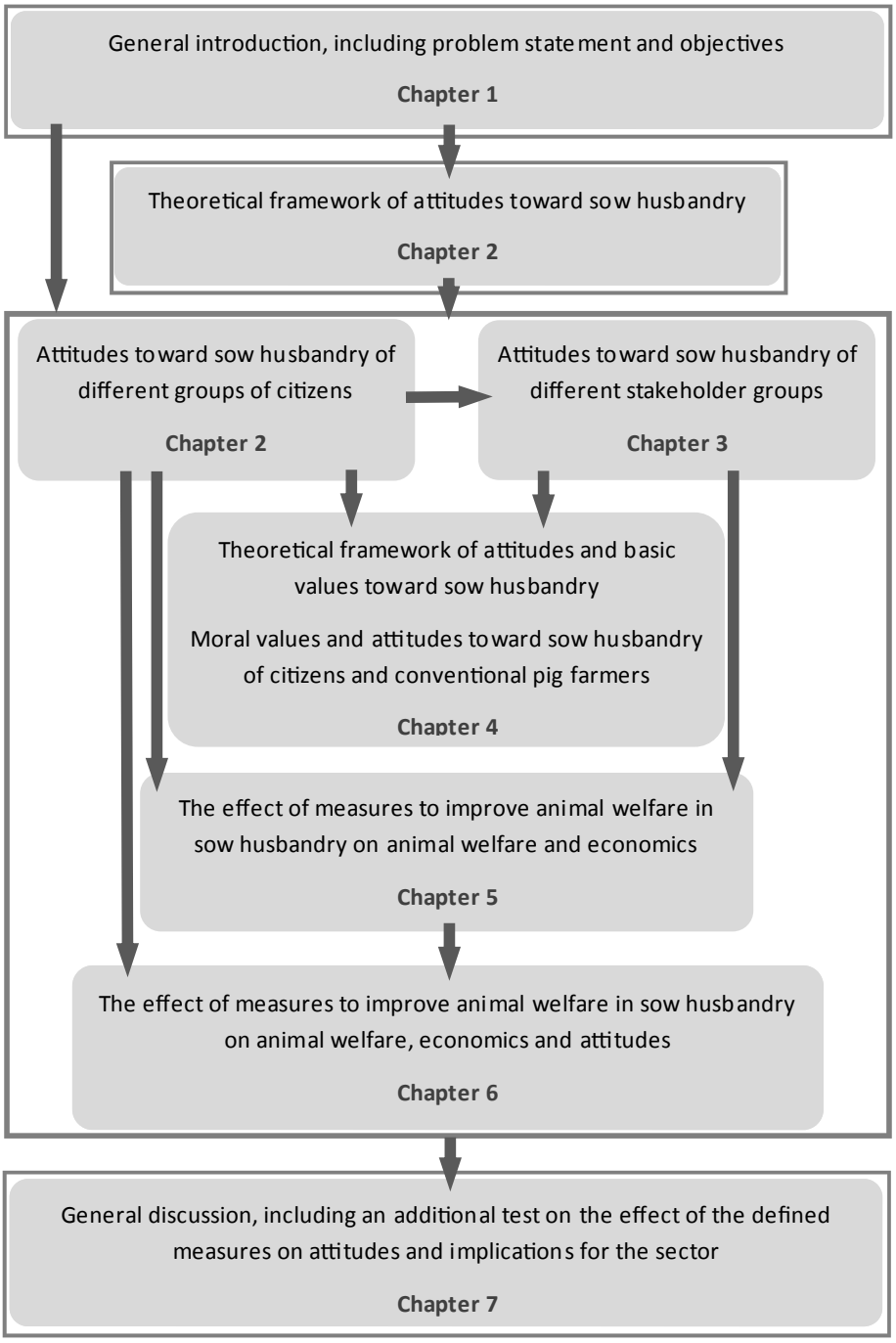


Figure 1.2 Schematic outline of this thesis.

husbandry described in Chapter 3, it will be studied how basic values can be useful to close the gap in attitudes toward sow husbandry between these stakeholders.

Chapter 5 describes a simulation model that estimates the effects of measures to improve animal welfare in sow husbandry on animal welfare and farm income. Several of these measures will be defined and their effects on animal welfare and farm income will be estimated with the simulation model. Based on the estimated effects, the different measures will be compared in terms of cost-effectiveness.

Chapter 6 extends the simulation model described in Chapter 5 so that the effects of measures to improve animal welfare in sow husbandry on citizens' attitudes is included. The same measures as described in Chapter 5 will be used to estimate their effects on animal welfare, farm income and citizens' attitudes. All these effects will be integrated with data envelopment analysis to calculate which of these measures is overall most efficient in terms of their effects on animal welfare, farm income and citizens' attitudes.

Chapter 7 discusses the findings described in Chapter 2 through 6. In addition, Chapter 7 verifies the estimated effects of measures to improve animal welfare in sow husbandry on citizens' attitudes. Furthermore, Chapter 7 discusses the applied interdisciplinary approaches used in this thesis and the implications for the pig sector with regard to citizens' attitudes.

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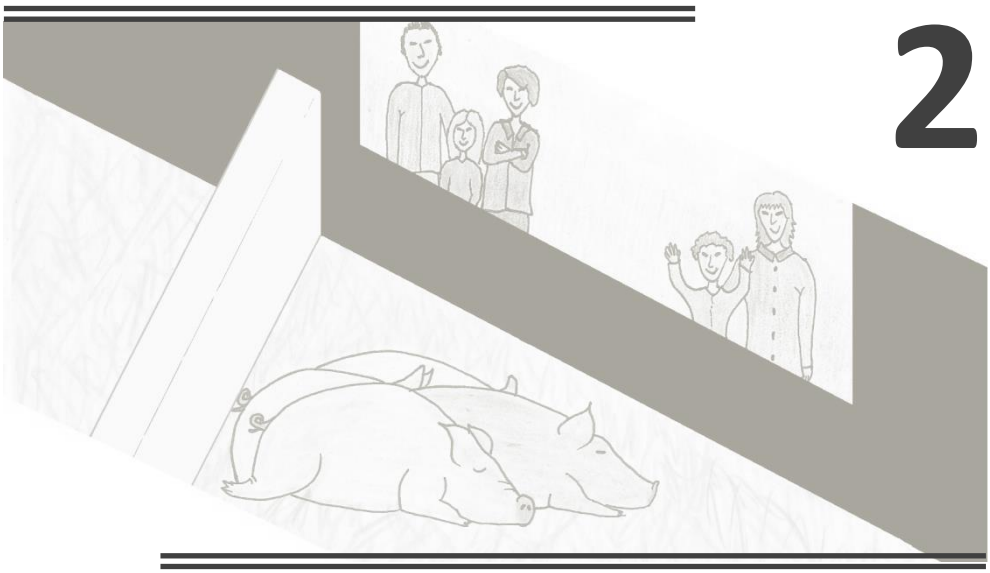

2

Attitudes of Dutch citizens toward animals, humans and the environment with regard to sow husbandry

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W.E. Kuiper
A.G.J.M. Oude Lansink
E.N. Stassen

Under review

Abstract

Citizens in Western society are criticizing animal husbandry systems more and more. One of the animal husbandry systems that is struggling with negative citizens' attitudes is the sow husbandry. To get citizens' support for sow husbandry, the sector needs to focus on attitudes related to different entities, i.e., animals, humans and environment. For aspects related to these entities, respondents of the present study could indicate their attitudes in additional care (AC) levels, i.e., the degree of extra attention necessary compared to the current situation. For all defined aspects the AC levels were on average 3.3 or higher on a five-point scale indicating that all these aspects are important in citizens' attitudes toward sow husbandry. Attitudes toward sow husbandry differed in weight and were most negative with respect to the effect of the use of antibiotics on both animals and consumers, the number of animals kept per square meter, the possibility for animals to go outside, food safety risks, public health risks and environmental waste. All these attitudes and their weight should be taken into account in the development of animal welfare measures for sow husbandry to improve citizens' attitudes.

Based on AC levels, four clusters of citizens could be formed. Only the smallest cluster (7.1% of the respondents) showed no or slightly negative attitudes toward sow husbandry. The other three clusters showed negative attitudes toward sow husbandry with respect to all defined aspects, indicating that a vast majority of Dutch citizens has negative attitudes toward sow husbandry. The clusters differed in socio-demographic features. These features were in most cases not distinctive in the two biggest clusters, but were distinctive in the two smallest clusters, e.g., gender, education and childhood residence. The distinctive socio-demographic features can be indicative for attitudes toward sow husbandry and may be useful in the communication between the pig sector and citizens.

Keywords

Attitudes, citizens, clusters, sow husbandry

2.1 Introduction

How animals are kept and treated in animal husbandry systems in Western societies is more and more criticized by the public (Harper and Henson, 2001; Ingenbleek et al., 2004; Meuwissen and van der Lans, 2005; Norwood and Lusk, 2009; Rollin, 2004; Verbeke and viaene, 2000). Animal husbandry changed drastically after World War II when it was, for several reasons, decided to produce cheap and plentiful food for the public (Rollin, 2004). For this production, the traditional animal husbandry system had to make way for a system that focused on efficiency and productivity. This focus meant that intensive animal husbandry arose, in which animals were confined and automation was used to fulfil routine tasks to replace human labor (Fraser et al., 2001). The development of intensive animal production systems has resulted in a decreased number of farms, an increased number of animals per farm and an increased production per animal (Bock and van Huik, 2007a; Fraser et al., 2001; Fraser, 2003; Rollin, 2004). The increase in animals per farm has changed human-animal relationships within farms (Bock and van Huik, 2007a; Bock et al., 2007b; Buller, 2004) and animal treatment (Fraser, 2003). The changes of intensified farming methods, as well as the higher public awareness of animal welfare, has resulted in a change in attitudes toward animal husbandry (Fraser et al., 2001; Fraser, 2003; Kanis et al., 2003). As a consequence, the impact of citizens' attitudes on animal husbandry and their 'license to produce', i.e., societal acceptance for the way of animal husbandry (Mureau, 2000), is increasing. Therefore, it is essential that the animal production sector takes citizens' attitudes into account.

One of the animal production systems that is struggling with negative citizens' attitudes is the sow husbandry (Barnett et al., 2001; Boogaard et al., 2011a; De Greef et al., 2006; Marchant-Forde, 2009; María, 2006; Schröder and McEachern, 2004). Citizens show negative attitudes toward issues such as pig housing (e.g., surface, social contact and environmental enrichment), interventions (e.g., castration and tail docking) without anesthesia and the use of antibiotics (Barnett et al., 2001; Boogaard et al., 2011b; Frederiksen et al., 2010; Lagerkvist et al., 2006; Marchant-Forde, 2009; Millman, 2011). When attitudes toward these issues become public, the pig sector reacts ad-hoc and adjusts only those specific issues. After these adjustments, citizens' attitudes do not improve as negative attitudes toward sow husbandry keep existing (Boogaard et al., 2011b; Meuwissen and van der Lans, 2005; Verbeke and viaene, 2000). A reason for this can be that, because of the ad-hoc response of the sector, attitudes toward the specific issue became more positive but attitudes toward other issues became negative because of the

consequences of the adjustments. Attitudes toward these other issues are included by citizens in their judgment of issues of sow husbandry, what makes their view broader than just the issue.

In the judgment of issues related to sow husbandry, citizens consider attitudes with respect to different entities, i.e., animals, humans and the environment (Beekman et al., 2002; Blokhuis et al., 2003; Harper and Henson, 2001; Mepham, 2000), in respect to several aspects. All these aspects will be taken into account in the judgment of issues related to sow husbandry, even if these aspects are not directly related to the issue (Knight et al., 2003). When the aspects that are not directly related to the issue are not taken into consideration in the development of animal welfare measures for sow husbandry, the consequence will be a shift in negative attitudes toward sow husbandry. For example, citizens are criticizing piglet mortality. To minimize piglet mortality the sector introduces 'motherless care'. With motherless care some of the piglets from large litters are raised without a mother but have a good chance of survival due to sufficient milk intake through artificial teats. Although piglet mortality drops, citizens are now critical about the fact that these piglets are raised without the care of a mother and the negative welfare impact on piglets. Another example is criticism about castration of piglets without the use of anesthetics because of the negative effect on animal welfare (Frederiksen et al., 2010; Lagerkvist et al., 2006). However, when castration would be put to an end, citizens criticize the risk of boar taint in non-castrated pig meat (Frederiksen et al., 2010; Lagerkvist et al., 2006).

In the attempt to broaden citizens' support for sow husbandry, the sector needs to focus on relevant aspects related to entities associated with sow husbandry, i.e., animals, humans and the environment. Before the sector can focus on these aspects it is necessary to know what citizens' attitudes toward sow husbandry with respect to these aspects are. Many studies on attitudes toward sow husbandry and toward pig husbandry in general have been carried out (e.g., (Boogaard et al., 2011b; Frederiksen et al., 2010; Krystallis et al., 2009; Lagerkvist et al., 2006; Meuwissen and van der Lans, 2005; Ngapo et al., 2003; Petit and van der Werf, 2003). However, none of these studies evaluate the three entities and related aspects that are relevant for attitudes toward sow husbandry at the same time. The interplay between the pig sector and citizens would improve with knowledge of citizens' attitudes with respect to the three entities associated with sow husbandry, so that negative citizens' attitudes are understood and citizens' support for measures developed by the sector improves. Therefore, the first objective of this study was to determine

attitudes of Dutch citizens toward sow husbandry with respect to relevant aspects related to animals, humans and environment.

Attitudes are influenced by convictions and values, interests, emotional experiences, knowledge and socio-demographic features, and differ between groups of people (Boogaard et al., 2006; Knight and Barnett, 2008; Knight et al., 2004). For the pig sector it is interesting to know if citizens can be grouped based on their attitudes toward sow husbandry, and what the differences between these groups are, to be able to anticipate on group characteristics. Therefore, the second objective was to group citizens based on their attitudes toward sow husbandry and determine and compare socio-demographic features of these groups.

2.2 Framework

As a first step in this study, a theoretical framework was described (Figure 2.1). The framework includes aspects of sow husbandry that play a role in citizens' attitudes toward relevant issues of sow husbandry. We considered issues to be relevant when they were presented as media items from the year 2009 until 2011 on the website of animal welfare organizations (Dierenbescherming, 2011; Stichting Varkens in Nood, 2011; Wakker dier, 2011). The found issues of relevance were: piglet mortality, pig housing, scale increase, interventions (castration, tail docking), euthanasia, sow lifespan, litter size, weaning age, motherless care, use of antibiotics and use of anesthetics. The use of anesthetics was excluded from the framework because it is covered by the castration issue because the castration discussion predominantly focused on whether or not to use anesthetics during the castration process.
With regard to the aforementioned issues of sow husbandry, people have attitudes with respect to different entities, i.e., animals (i.e., pigs), humans (both animal keepers and consumers) and the environment. These entities are included in the framework (Figure 2.1). Per entity, different categories were formulated within each category the associated aspects that are relevant for attitudes toward sow husbandry. The issues of sow husbandry were included in the framework as aspects because people have direct attitudes toward these issues. The rest of the aspects are based on literature1, information from the pig sector and expert knowledge.

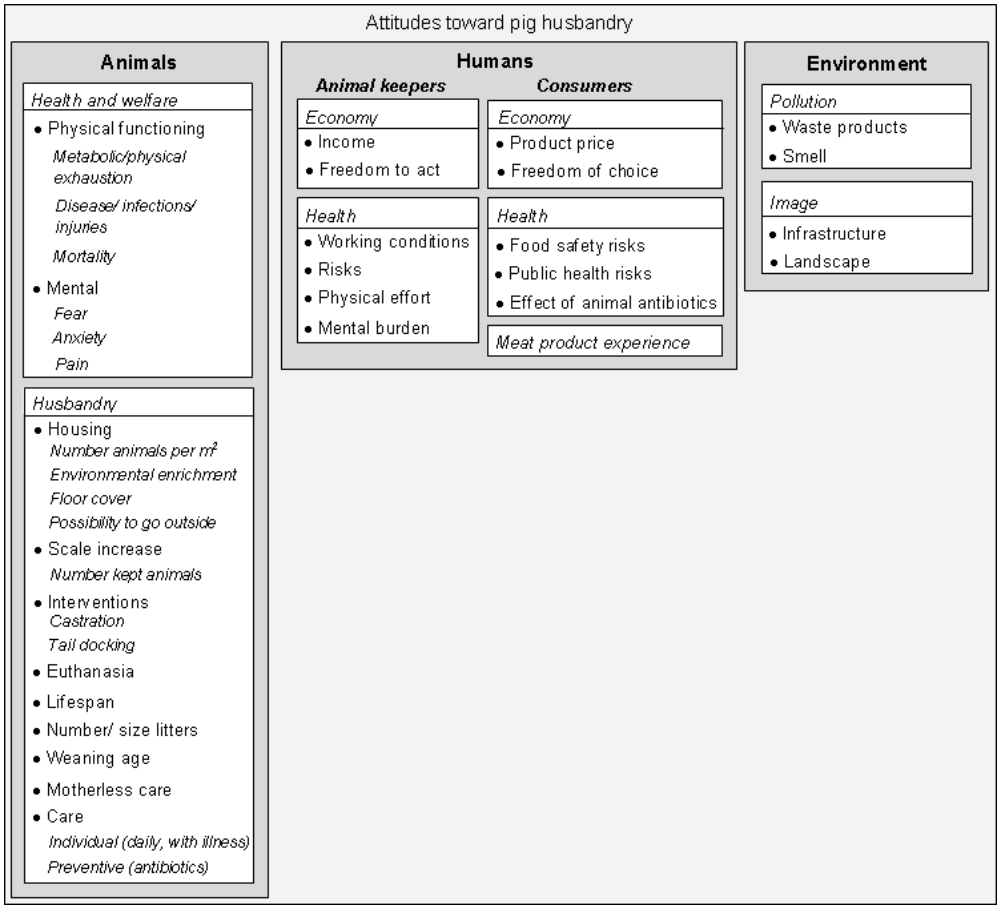

Figure 2.1 Framework for the assessment of attitudes toward sow husbandry. Per entity of sow husbandry (i.e., animals, humans and the environment) categories with aspects that play a role in attitudes toward sow husbandry are presented.

2.3 Material and methods

Participants

A questionnaire was distributed in October 2011 via the internet to a group of 2,572 Dutch citizens. This group of citizens was approached by a research institute that is specialized in online surveys (CentERdata, Tilburg, the Netherlands). This institute has a directory of Dutch citizens representative for the Netherlands who voluntarily participate in surveys. The response rate was 65.9% (1,695 out of 2,572). Only respondents who fully completed the questionnaire (n=1,607, 62.5%) were included for further analyses. For all socio-

demographic features represented in Table 2.1, the group of respondents was representative of the Netherlands, except for gender and age. The average age of study respondents was higher than average for the Netherlands. The age categories 20-40 years, 40-65 years and 65-80 years included 13.8%, 53.2% and 27.8% of the participants, respectively, while the Dutch population consisted of 31.2%, 44.8% and 14.4%, respectively (Central Bureau of Statistics, 2011). In the Dutch population, there were slightly more females (50.5%) than males (Central Bureau of Statistics, 2010). In this study there were more male respondents (53.3%) than female respondents (47.7%).

Table 2.1 Number of respondents (n) per category of the socio-demographic features.

Socio-demographic feature	Category	n	Socio-demographic feature	Category	n
Gender	Male	880	Education	Primary school	76
	Female	727		Secondary school (low)	438
Age (years)	15-24	57		Secondary school (high)	197
	25-34	74		Vocational	256
	35-44	226		BSc	430
	45-54	316		MSc	208
	55-64	428			
	65-older	506			

Questionnaire

On the basis of the framework, we developed a questionnaire. The questionnaire was formulated so that as little information as possible was given. Given information can influence respondents attitudes, what can result in a distorted picture of citizens' current attitudes. The first part of the questionnaire contained a question for each entity, i.e., animals, humans and the environment. In these three questions, all aspects from the framework were processed. We wanted to know respondents attitudes toward sow husbandry with respect to all these aspects. Attitudes cannot be identified by levels and therefore we assumed that additional care (AC) levels, i.e., the degree of extra attention that was found necessary compared to the current situation, is a good representation of attitudes. It was assumed that negative attitudes were represented in higher AC levels. Respondents were asked to indicate AC levels for each aspect on a Likert scale of 1 (no AC necessary) to 10 (maximal AC necessary). A ten-point scale was chosen because people that grew up in the Netherlands are familiar with this scale. The second part of the questionnaire included questions about socio-demographic features, i.e., gender, age, level of education, religious (yes, no or a little), pets (yes or no) type of meat eaten, urban character of residence, region of residency in the Netherlands (north, middle or south) and

size of childhood residence. The full questionnaire is available by contacting the first author of this paper.

Data Analysis

Before the statistical analyses were performed, the AC levels were decreased from a ten-point Likert scale to a five-point Likert scale (1: no AC necessary, 2: little AC necessary, 3: moderate AC necessary, 4: strong AC necessary and 5: utmost AC necessary; levels 1 and 2 became level 1, levels 3 and 4 became level 2, etcetera).

Descriptive statistical analyses were carried out to identify AC levels that Dutch assigned to aspects of sow husbandry. Based on AC levels given by the respondents, a cluster analysis (using Ward's method) was performed in order to cluster respondents. The probability that respondents in a certain cluster gave higher or lower AC levels than respondents in the other clusters was calculated with ordered multinomial logistic regression. Binary logistic regression was performed to analyse whether respondents in each cluster could be identified by specific socio-demographic features. These calculations were based on one cluster containing 100% of respondents per socio-demographic feature, instead of all clusters together containing 100% of respondents, to cover for the representativeness effect of gender and age. The percentage of respondents per category of socio-demographic feature from one cluster was compared with the percentages of the other clusters.
IBM SPSS Statistics 19 (IBM Corporation, New York, United States) was used for descriptive statistical analyses and EViews6 (IHS EViews, Irvine, United States) was used for all other analyses.

2.4 Results

In general, Dutch citizens were of the opinion that additional care (AC) was necessary for all defined aspects of sow husbandry (Table 2.2). The AC levels for all these aspects were on average 3.3 or higher on a five-point scale. For all the aspects, except for metabolic/ physical exhaustion, freedom to act, product price, freedom of choice and meat product experience, more than 50 % of the respondents indicated that strong or utmost AC was necessary. The highest percentages of respondents indicated utmost AC necessary for the

possibility for animals to go outside (39.4%), the effect of the use of antibiotics on animals (50.5%) and on consumers (50.5%), food safety risks (38.3%), public health risks (42.1%) and environmental waste (36.4%). For all these aspects, the average AC level was 4.0 or higher.

Clusters of citizens

Cluster analysis was performed to study whether different respondents could be clustered based on the levels of AC they indicated to be necessary for aspects of sow husbandry. Four clusters were formed which could be identified as the high-AC, moderate-AC, max-AC and no-AC cluster. The high-AC cluster had the most respondents (40.1%) and gave relatively high levels of AC. The moderate-AC cluster had 38.8% of the respondents and gave moderate AC levels. The max-AC cluster had 14.0% of the respondents and gave the highest AC levels compared to the other clusters. The no-AC cluster had the least respondents (7.1%) and gave AC levels below average. The average AC levels per cluster of respondents per category of aspects of sow husbandry are presented in Figure 2.2. In this figure the separate AC levels per aspect are combined per category for clarification of results. Results of the ordered multinomial logistic regression showed that the probability that respondents of each cluster gave different AC levels than respondents in the other clusters was significant ($P<0.04$) for all defined aspects. For these aspects, the high-AC cluster gave AC levels between 3.2. and 4.5 with the highest AC levels given to aspects related to the animal and human health. The moderate-AC cluster gave AC levels between 3.0 and 3.8 to all defined aspects. The high-AC cluster gave the highest AC levels (>4.1) to all defined aspects compared to the other clusters. In contrast, the no-AC cluster gave the lowest AC levels (<3.3) for all defined aspects compared to the other clusters. This cluster gave, on average, AC levels lower than 2.1 for aspects related to the animal, except for the effect of the use of antibiotics on the animal (average AC level: 3). The AC levels for aspects related to humans and the environment given by the no-AC cluster were on average lower than 3, except for enough income for the farmer (average AC level: 3.1) and the effect of the use of antibiotics on the consumer (average AC level: 3.2).

Table 2.2 Percentage respondents per additional care (AC) level, i.e., the degree of extra attention that was found necessary compared to the current situation, per aspect of sow husbandry and the average AC level on a five-point scale.

		AC level*					Average
Entity	**Aspects**	*NAC*	*LAC*	*MAC*	*SAC*	*UAC*	**AC level**
Animals	Quality/quantity feed	8.8	9.5	32.7	33.7	15.3	3.4
	Rate sickness/infection/injury	3.7	5.6	25.2	39.6	25.9	3.8
	Mortality	4.5	5.8	33.5	36.5	19.7	3.6
	Fear/anxiety	2.4	4.9	27.7	36.3	28.7	3.8
	Pain	2.4	5.1	26.1	35.5	30.9	3.9
	Number of kept animals	3.5	4.8	26.5	33.7	31.5	3.8
	Environmental enrichment	5.9	7.1	32.5	32.9	21.6	3.6
	Number of animals per m2	2.8	3.8	26.1	34	33.3	3.9
	Floor cover	3.1	4.8	27.1	36.6	28.4	3.8
	Possibility of going outside	3.3	4.4	22.7	30.2	39.4	4.0
	Tail docking	5.9	7.9	30.4	27.4	28.4	3.6
	Castration	5.8	7.4	32.4	26.5	27.9	3.6
	Time euthanasia	5.7	6.7	33.6	29.1	25	3.6
	Lifespan sow	4.2	5.4	34.4	32.1	23.9	3.7
	Number of litters per sow	4.9	5.1	34.9	31.2	23.9	3.6
	Litter size	5.7	6.3	36.6	30.6	20.8	3.5
	Weaning age	4.8	6.6	35.2	31.5	21.9	3.6
	Motherless care	4.6	6.9	29.5	31.7	27.3	3.7
	Care for individual animal	4.1	5.1	28.6	33.1	29.1	3.8
	Use of antibiotics (animal)	3	2.6	21.1	22.8	50.5	4.2
Humans (animal keepers)	Enough income	3.9	6	33.6	41.4	15.2	3.6
	Freedom to act	5.9	10.2	42.7	31.1	10.1	3.3
	Working conditions	4.2	7.6	36.3	37.4	14.6	3.5
	Health risks	3.4	4.7	28.9	36.6	26.4	3.8
	Physical burden	4.3	7.1	35	37.5	16.2	3.5
	Mental burden	4.4	7.2	35	37	16.6	3.5
Humans (consumers)	Product price	7.9	10.8	35.8	31.6	13.9	3.3
	Freedom of choice	7.4	10.4	34.2	33.5	14.4	3.4
	Food safety risks	3	4.6	23.3	30.8	38.3	4.0
	Public health risks	2.8	3.6	22.3	29.2	42.1	4.0
	Use of antibiotics (human)	2.7	3.2	19.8	23.8	50.5	4.2
	Meat product experience	8	7.3	36.9	29.8	18	3.4
Environment	Environmental waste	2.4	3.6	20.3	37.3	36.4	4.0
	Smell	5.1	8.7	32.3	31.5	22.4	3.6
	Change in infrastructure	3.5	6.1	31	36.9	22.5	3.7
	Image landscape	2.4	11.7	32.3	32.3	21.3	3.6

* NAC: no AC necessary, LAC: little AC necessary, MAC: moderate AC necessary, SAC: strong AC necessary, UAC: utmost AC necessary.

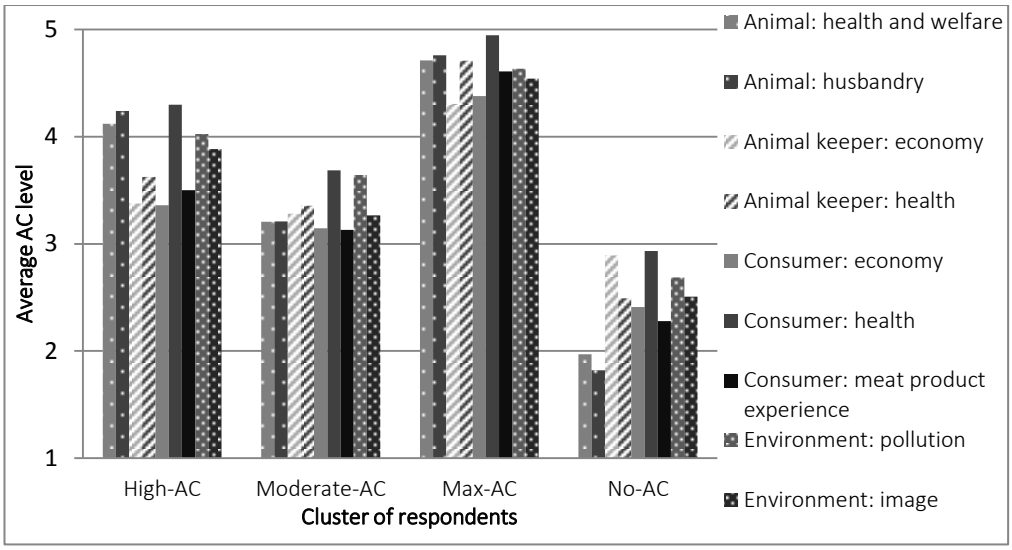

Figure 2.2 Average additional care (AC) level, i.e., the degree of extra attention that was found necessary compared to the current situation, per category of aspects with regard to sow husbandry per cluster of respondents. AC levels: 1: no AC necessary, 2: little AC necessary, 3: moderate AC necessary, 4: strong AC necessary, 5: utmost AC necessary. Percentage respondents: high-AC cluster: 40.1% (n=645), moderate-AC cluster: 38.8% (n=623), max-AC cluster: 14.0% (n=225), no-AC cluster: 7.1% (n=114).

The four clusters of respondents differed in socio-demographic features (Table 2.3). For some of these features, i.e., having a pet, living in which part of the Netherlands and urban character of residence, there were no significant effects between clusters. Therefore, these socio-demographic features were excluded from the table. Female respondents had a higher probability ($P<0.01$) to be in the high-AC or max-AC cluster than in the other two clusters. The max-AC cluster was the only cluster with more female than male respondents. Respondents in the age from 55 to 64 years, had a higher probability ($P<0.05$) to be in the max-AC cluster than in the other clusters. Respondents of 65 years or older had a higher probability ($P<0.02$) to be in the max-AC cluster than in the moderate-AC and no-AC cluster. Respondents with lower secondary school as highest level of education had a higher probability ($P<0.01$) to be in the max-AC cluster than in the other clusters. Respondents that were not religious had a higher probability ($P<0.03$) to be part of these other clusters than to be part of the max-AC cluster. Respondents that were a little religious, i.e. believing that there is 'something' (Drees, 1999), had a higher probability ($P<0.05$) to be in the max-AC cluster than in the other clusters. Respondents raised in a small village had a higher

Table 2.3 Significant differences between clusters of respondents in socio-demographic features. Clusters determined based on additional care (AC) levels, i.e., the degree of extra attention they found necessary compared to the current situation, they assigned to aspects of sow husbandry,.

Socio-demographic feature	Category	n	Cluster*			
			High-AC	*Moderate-AC*	*Max-AC*	*No-AC*
Gender:	Male	880	50.5 [a]	59.7 [b]	48.4 [a]	64.0 [b]
	Female	727	49.5 [a]	40.3 [b]	51.6 [a]	36.0 [b]
Age:	15-24	57	1.9 [a]	5.3 [b]	3.1	4.4
	25-34	74	4.7	5.1 [a]	1.8 [b]	7.0 [a]
	35-44	226	13.3	16.5 [a]	8.9 [b]	14.90
	45-54	316	21.1 [a]	20.1 [a]	11.6 [b]	25.4 [a]
	55-64	428	26.5 [a]	23.4 [a]	36.4 [b]	25.4 [a]
	65-older	506	32.6 [c]	29.3 [a]	38.2 [b]	22.8 [a,]
Education:	Primary school	76	4.2	5.0	5.8	4.4
	Secondary school (low)	438	26.0 [a]	24.8 [a]	40.4 [b]	22.1 [a]
	Secondary school (high)	197	12.7	12.7	8.4	15.0
	Vocational	256	16.1	15.9	16.0	15.0
	BSc	430	27.8	26.8	23.1	28.3
	MSc	208	13.2 [a]	14.8 [a]	6.2 [b]	15.0
Religious:	Yes	451	26.7	28.3	29.3	32.5
	No	814	51.8 [a]	51.7 [a]	42.2 [b]	55.3 [a]
	A little	342	21.6 [a, c]	20.1 [a, c]	28.4 [b]	12.3 [a,]
Childhood residence:	Randstad**	411	30.1 [a, c]	23.1 [b, c]	26.7 [c]	11.4 [d]
	Big city	210	11.0 [a]	13.0 [a]	20.4 [b]	10.5 [a]
	Small city	271	18.1	16.7	15.6	13.2
	Big village	264	15.0 [a]	19.1 [b]	11.6 [a]	19.3
	Small village	451	25.7 [a]	28.1 [a]	25.8 [a]	45.6 [b]
Eating meat:	Often pig meat	606	31.6 [a, c]	44.3 [b]	28.4 [a,]	54.4 [a,]
	Sometimes pig meat	701	44.8	43.3	45.8	34.2
	Other meat (no pig meat)	155	10.2 [a]	8.5 [c]	13.8 [a,]	4.4 [b]
	Organic meat	94	8.2 [a]	2.9 [b]	9.3 a	1.8 [b]
	Vegetarian	51	5.1 [a]	1.0 [b]	2.7	5.3 [a]
Ever visited a pig farm:	Yes	727	42.8 [a]	46.5 [a]	39.6 [a]	63.2 [b]
	No	880	57.2 [a]	53.5 [a]	60.4 [a]	36.8 [b]
Get information about pig husbandry:	Yes	1265	85.0 [a]	71.9 [b]	79.6 [a]	78.9
	No	342	15.0 [a]	28.1 [b]	20.4 [a]	21.1

Percentages are calculated on the basis of one cluster including 100% of respondents per socio-demographic feature.

* High-AC cluster: respondents with average AC levels around 4 (n=645), moderate-AC cluster: respondents with AC levels around 3 (n=623), max-AC cluster: respondents with AC levels above 4 (n=225). No-AC cluster: respondents with AC levels below 3 (n=114).

** Randstad is the most urban area in the Netherlands.

[a, b] Per category of the socio-demographic feature, respondents had a significantly (P <0.05) higher/lower probability to be in the cluster with 'a' than in the cluster with 'b'.

[c, d] Per category of the socio-demographic feature, respondents had a significantly (P <0.05) higher/lower probability to be in the cluster with 'c' than in the cluster with 'd'.

probability (P<0.01) and respondents raised in Randstad (the most urban part of the Netherlands) had a lower probability (P<0.02) to be in the no-AC cluster than in the other clusters. More than half of the respondents in the no-AC cluster indicated to often eat pig meat. Respondents that often ate pig meat had a higher probability (P<0.05) to be in the no-AC cluster than in the other clusters. Most respondents of the no-AC cluster (63.2%) had visited a pig farm at least once, which was not the case for the other clusters in which less than half of the respondents had visited a pig farm at least once. Respondents that visited a pig farm had a higher probability (P<0.01) to be in the no-AC cluster than in the other clusters.

2.5 Discussion

In the present study we determined Dutch citizens' attitudes toward sow husbandry. These attitudes were assumed to be represented in levels of additional care (AC), i.e., extra attention that was found necessary compared to the current situation, assigned to different aspects of sow husbandry. Respondents were asked to indicate their AC levels in a questionnaire. The questionnaire was set up in such a way that as little information as possible was given to prevent influencing priori attitudes of respondents by adding knowledge with information, e.g. give the percentage of piglet mortality. Respondents' attitudes may have been influenced by the mentioning of aspects in the questionnaire they were not aware of before. Although respondents were not aware of these aspects before, they still base their attitudes on their own knowledge and feelings.

The aspects to which respondents assigned AC levels, were related to entities associated with sow husbandry, i.e., animals, humans (animal keeper and consumer) and environment. The entities and aspects that were relevant, based on literature, information from the sector and expert knowledge, were combined in a framework that was developed before the questionnaire was made. Data from the questionnaire shows that for all aspects from the framework the AC levels were higher than 3.0 (neutral), meaning that attitudes toward sow husbandry were negative with respect to all these aspects. This means that all these aspects should be kept in mind when discussing citizens' attitudes and that the framework is valid as directive for attitudes that are important for sow husbandry. The most negative attitudes toward sow husbandry were related to the effect of the use of antibiotics on both the animals and humans. These negative attitudes may partly be explained by negative publicity about the use of antibiotics before and during the period in

which the questionnaire was presented. Besides negative publicity, negative attitudes toward the use of antibiotics would most likely still exist because of the fear of antibiotic residuals in meat and their effects on human health (Frederiksen et al., 2010; Huber-Eicher and Spring, 2008; Ngapo et al., 2003). This means that in their attitude toward the use of antibiotics in animals, citizens do not only include attitudes with respect to animals but also include attitudes with respect to humans. Related to human health, citizens' attitudes toward sow husbandry were also highly negative with respect to the food safety risks and public health risks. These negative attitudes will also be considered in attitudes toward the use of antibiotics because it is all linked to human health.

The highest negative attitudes with respect to the animal entity were, next to the use of antibiotics, related to animal housing. Especially the number of animals per square meter and the possibility for animals to go outside scored high in AC levels. Negative citizens' attitudes toward confined animal housing has been shown in previous studies as well (Boogaard et al., 2010; Meuwissen and van der Lans, 2005). Confined animal housing is partly applied to minimize environmental waste and greenhouse gas emission. These environmental issues can be controlled in closed housing systems. Although environmental waste can be controlled, citizens' attitudes toward sow husbandry with respect to environmental waste were negative. Either citizens do not know that environmental waste derived from sow husbandry can be controlled by confined housing systems, or environmental waste is linked to other aspects, such as smell. It was mentioned by Cole (2009) that citizens do not make a connection between day-to-day animal practices and the environment. However, respondents of our study seemed to be able to connect sow husbandry to environmental waste. That respondents made this connection can be the result of discussions around sow husbandry emissions and media items.
Based on our results it can be stated that all defined aspects of sow husbandry are important in citizens' attitudes toward sow husbandry. Therefore, all these aspects should be integrated in the development of animal welfare measures for sow husbandry to improve citizens' attitudes. Some attitudes of citizens seem to be stronger, i.e., weigh more, than others. The attitude weights should be taken into account in the development of measures for sow husbandry and could be based on the results of the present study.

Based on AC levels, four clusters of respondents could be formed. Three of these clusters, i.e., high-AC, moderate-AC and max-AC, showed negative attitudes toward sow husbandry with respect to all defined aspects. The smallest cluster (7.1% of the respondents), i.e., no-AC, was the only cluster that showed no or slightly negative attitudes toward sow

husbandry. These results indicate that a vast majority of Dutch citizens has negative attitudes toward sow husbandry with respect to all defined aspects. Clusters differed in some of the socio-demographic features. Females had a higher probability to be in the two clusters with the most negative attitudes than in the other two clusters. This gender effect corresponds to other studies that showed that females were less supportive of the use of animals and were more critical about animal welfare than males (Frederiksen et al., 2010; Harper and Henson, 2001; Herzog, 2007; Knight et al., 2004; María, 2006; Prickett et al., 2010; Tuyttens et al., 2010; Vanhonacker et al., 2010a). In the two biggest clusters, i.e., high-AC (40.1% respondents) and moderate-AC (38.8% respondents), gender was the only distinctive feature. The other two clusters had more distinctive features. Respondents older than 55 years, being a little religious (i.e., believing there is 'something') or having lower education had a higher probability to be in the high-AC cluster compared to the other clusters. The age effect corresponds to some studies (Frederiksen et al., 2010; Knight et al., 2004), but conflicts with others (María, 2006; Vanhonacker et al., 2010a). A reason for differences in age effect between studies could be that studies were performed in different countries, that age was biased by education level or other characteristics or that the focus of the studies differed. The present study focused on specific aspects of a specific type of animal use, i.e., sow husbandry, which is comparable to the studies of Knight (2004) and Frederiksen (2010). The effect of education was previously shown in meat purchases, where lower educated people took animal welfare more into account than higher educated people (Prickett et al., 2010). It is possible that there is an interaction between education level, age and gender (Kendall et al., 2006), which means that education levels alone are not indicative of the level of intelligence in males and females. This difference in education level between males and females may be explained by the fact that until approximately fifty years ago it was not common for women to study. The interaction between age and education may explain why the high-AC cluster included relatively more females and less highly educated respondents than the other clusters.

Respondents that often ate pig meat, were raised in a small village or visited a pig farm at least once had a higher chance to be in the no-AC cluster. These results indicate that people who often eat pig meat have positive attitudes toward sow husbandry. This corresponds to a previous study which showed that people who eat meat support the use of animals more than people who do not eat meat (Knight et al., 2004). Support of the use of animals also seems to be affected by the region in which people are raised because of the effect on commitment and knowledge of sow husbandry (Boogaard et al., 2006). Inhabitants of small villages are often more involved in animal husbandry than inhabitants of bigger cities and Randstad (most urban area in the Netherlands), because they live closer

by animal farms. Respondents in the no-AC cluster were probably more involved in animal husbandry than respondents in the other clusters because of their childhood residence. This involvement probably resulted in more commitment and knowledge with regard to sow husbandry. This commitment and knowledge may be reflected in the experience of visiting pig farms. Over 60% of the respondents in the no-AC cluster had visited a pig farm at least once, while in the other clusters this was less than 47%. The knowledge and experience gained by visiting a pig farm has an effect on attitudes toward sow husbandry (Boogaard et al., 2011b; Boogaard et al., 2006). The knowledge and commitment of respondents in the no-AC cluster seemed to have resulted in positive attitudes toward sow husbandry. These positive attitudes could be the result of a better understanding of the effect of a system on both animals and humans (Knight and Barnett, 2008).
It is possible that people in the no-AC cluster, i.e., relatively more males with more knowledge, are people that are more often involved in policy development for sow husbandry. If that is the case, there is a discrepancy between policy makers and the general public. Policy makers should be aware of this discrepancy. The discrepancy may be related to socio-demographic features. The differences in socio-demographic features between clusters can be indicative for attitudes and may be useful in the communication between the pig sector and citizens.

In conclusion, the present study has shown that all defined aspects relevant to issues of sow husbandry are important in citizens' attitudes toward sow husbandry. That all these aspects are important indicates that our framework is valid as directive for the assessment of attitudes toward sow husbandry. Attitudes toward sow husbandry differed in weight and were most negative with respect to the effect of the use of antibiotics on both animals and consumers, the number of animals kept per square meter, the possibility for animals to go outside, food safety risks, public health risks and environmental waste. The attitude weights may change after implementation of animal welfare measures in sow husbandry, what results in a shift of negative attitudes toward sow husbandry. To decrease these negative attitudes, attitude weights related to all defined aspects, directly or indirectly involved, should be taken into account in the development of animal welfare measures for sow husbandry.
Based on AC levels, respondents could be clustered into four clusters. The smallest cluster had no or slightly negative attitudes toward sow husbandry, with the least negative attitudes related to animals. The other three clusters all had negative attitudes toward sow husbandry with respect to aspects related to animals, humans and the environment. The clusters differed in socio-demographic features. These features were in most cases not

distinctive in the two biggest clusters, but were distinctive in the two smallest clusters. The distinctive socio-demographic features may be useful in the communication between the pig sector and citizens.

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Note

[1] Literature we used for the development of the framework: (Barnett et al., 2001; Beekman et al., 2002; Boogaard et al., 2011a; Boogaard et al., 2011b; Cohen, 2010; Cohen et al., 2012; Driessen, 2010; Fraser, 1999; Frederiksen et al., 2010; Harper and Henson, 2001; Huber-Eicher and Spring, 2008; Kanis et al., 2003; Krystallis et al., 2009; Lagerkvist et al., 2006; Marchant-Forde, 2009; McGlone, 2001; Mepham, 2000; Meuwissen and van der Lans, 2005; Michalopoulos et al., 2008; Millman, 2011; Ngapo et al., 2003; Petit and van der Werf, 2003; Te Velde et al., 2002; Tuyttens et al., 2010; Vanhonacker et al., 2010b; Vanhonacker et al., 2010a; Vanhonacker et al., 2008; Verbeke and Viaene, 1999; Verdoes and Swinkels, 2003; Von Essen and McCurdy, 1998; Webster, 2001).

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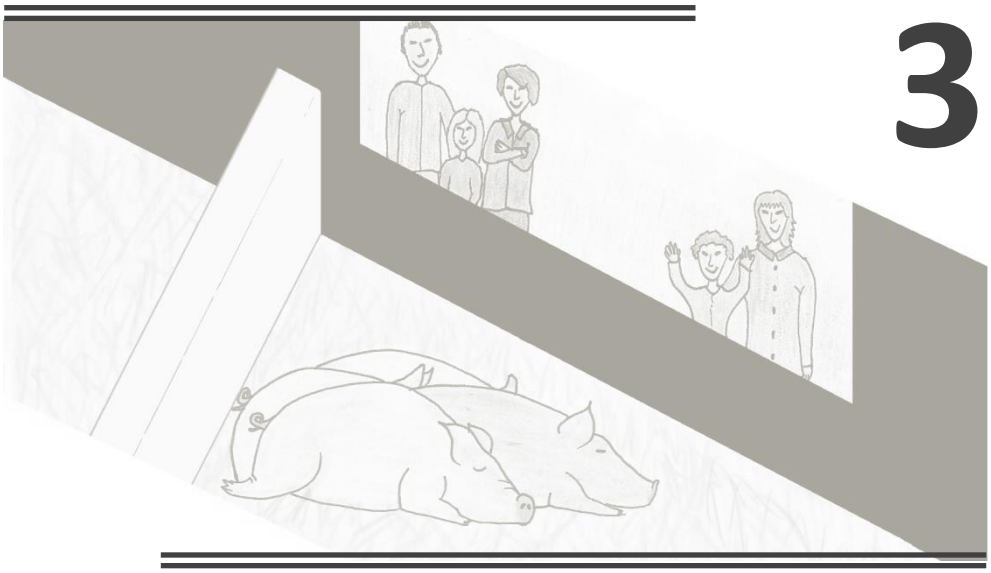

3

Attitudes of different stakeholders toward sow husbandry: a study to determine conflicting and matching attitudes toward animals, humans and the environment

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Under review

Abstract

Sow husbandry is struggling with negative attitudes of citizens. To be able to improve these attitudes, first it is important to obtain detailed knowledge about attitudes toward sow husbandry of different stakeholders. Therefore, the objectives of this study were 1) to determine and compare attitudes toward sow husbandry in respect to relevant aspects related to animals, humans and the environment of various stakeholders and 2) to determine and compare the acceptability of issues related to sow husbandry of various stakeholders. A questionnaire was distributed to citizens, conventional pig farmers, organic pig farmers, pig husbandry advisors and pig veterinarians. Respondents could indicate their attitude toward sow husbandry with respect to aspects related to animals, humans and the environment and they could indicate their opinion about the acceptability of issues of sow husbandry, e.g. piglet mortality and indoor pig housing. Based on measured attitudes toward sow husbandry and the acceptability of issues related to sow husbandry, the studied stakeholders could be divided into three distinctive groups. The group of citizens and organic pig farmers showed negative attitudes toward sow husbandry with respect to all defined aspects, the group of conventional pig farmers and pig husbandry advisors only showed negative attitudes toward sow husbandry with respect to only economic aspects and the group of pig veterinarians showed negative attitudes toward sow husbandry with respect to specific aspects. The different attitudes result in a lack of understanding and trust between the three distinctive groups. Therefore, communication between these groups is essential.

Keywords

Attitudes, sow husbandry, stakeholders

3.1 Introduction

The animal husbandry sector is struggling with negative public attitudes toward their sector. These public attitudes are, for instance, expressed in public debates with regard to animal husbandry (Barnett et al., 2001; Bergstra et al., 2014; Boogaard et al., 2011 a; Brom, 2000; De Barcellos et al., 2012; Krystallis et al., 2009; María, 2006; Mench, 2008; Meuwissen and van der Lans, 2005; Miele et al., 2011; Ngapo et al., 2003; Schröder and McEachern, 2004). In these public debates, the expressed negative attitudes of the public seem to be getting stronger over time. These attitudes have a negative effect on the animal husbandry's 'license to produce', i.e., the right of farms to exist (Mureau, 2000). To keep their license to produce, the animal husbandry sector tries to improve public attitudes.
Attitudes are influenced by interests (Boogaard et al., 2006), and interests depend on the context (Cohen et al., 2009). The context, for example sow husbandry, determines which interests are important for a person. Pig farmers have, besides other interests, a financial interest with regard to sow husbandry because they depend on the sales volume of their practice (Te Velde et al., 2002). The interests of organic pig farmers may differ from conventional pig farmers because of different views on animal welfare (Bock and van Huik, 2007a). The different views on animal welfare are expressed in their animal practices and their attitudes. Citizens' attitudes are influenced by their interests in a tasty piece of meat that is healthy and cheap and produced with good animal welfare (Te Velde et al., 2002). Also the interest in the environment, e.g., pollution, infrastructure and smell, play a role in citizens attitudes toward sow husbandry (Driessen, 2010; McGlone, 2001; Meuwissen and van der Lans, 2005; Ngapo et al., 2003).

Interests with regard to sow husbandry are related to different entities, i.e., animals, humans and environment. Attitudes toward each separate entity are developed, but depending on the context all these attitudes will be considered and combined (Cohen et al., 2009). The attitudes that are considered to be relevant will be combined and will give a final judgment about the context. For example, with regard to piglet castration, attitudes related to animal welfare and human health are being combined (Frederiksen et al., 2010; Lagerkvist et al., 2006). Surgical castration without anesthetics was found to be unacceptable by citizens because of the effect on animal welfare (Lagerkvist et al., 2006). However, putting castration to an end was rejected because of the fear of boar taint in meat from non-castrated pigs and people's reluctance to immunocastration because of uncertainty about the effect of residuals in meat on human health (Frederiksen et al., 2010; Lagerkvist et al., 2006).

Differences in interests can result in conflicting attitudes between stakeholders, e.g. citizens and pig farmers. Previous studies have shown that citizens' attitudes toward sow husbandry differ from attitudes of other stakeholders, e.g., pig farmers (Bracke et al., 2005; Lassen et al., 2006; Petit and van der Werf, 2003; Te Velde et al., 2002; Tuyttens et al., 2010; Van Huik and Bock, 2007; Vanhonacker et al., 2008). For example, citizens have a less positive attitude toward sow husbandry with respect to animal welfare than pig farmers (Te Velde et al., 2002; Vanhonacker et al., 2008). By making changes in the husbandry system, the pig sector tries to reduce the conflicting attitudes in order to improve citizens' attitudes toward sow husbandry . For these changes, measures are developed for issues related to sow husbandry, e.g., piglet mortality, piglet castration and pig housing. However, the changes achieved by these measures do not seem to have a positive effect on citizens' attitudes toward sow husbandry. In the development of measures for sow husbandry, the people that develop these measures, e.g. pig farmers and the government, will use their own interests as guidance in the decisions that have to be made. The differences in interests between measure developers and citizens will result in conflicting attitudes toward the developed measure between the stakeholders. Pig farmers may consider and combine other attitudes than citizens to come to a judgment about a measure. For example, the measure 'motherless care' is developed because it is assumed that citizens have negative attitudes toward sow husbandry with respect to piglet mortality. With motherless care a number of piglets from large litters will be separated from their mother to get sufficient milk intake through artificial teats. With this measure, piglet mortality will decrease. However, citizens' attitudes toward sow husbandry with respect to piglet mortality still seem to be negative. These negative attitudes are now related to other aspects, such as the raising of piglets without the care of a mother and the negative effect on piglet welfare. Citizens seem to consider different aspects separately without weighing them relative to each other in forming attitudes toward sow husbandry, while measure developers will weigh these aspects, e.g. animal welfare and economics, to find a balance. This balance is translated into the measure, which is the most optimal measure according to the measure developers. However, this measure will not improve citizens' attitudes as long as the separate aspects will not be considered in measure development.

Knowing that citizens' attitudes differ from their own, it is a challenge for the pig sector to anticipate on the attitudes of citizens toward sow husbandry. In order to develop measures for pig husbandry that will be accepted by all stakeholders, the different attitudes of stakeholders should be known. That attitudes of stakeholders of sow husbandry differ has been shown in several studies (Bergstra et al., 2014; Bock and van Huik, 2007a; Boogaard et

al., 2011 b; Boogaard et al., 2006; Bracke et al., 2005; Harper and Henson, 2001; Heleski et al., 2006; Knight et al., 2004; Krystallis et al., 2009; Lassen et al., 2006; María, 2006; Meuwissen and van der Lans, 2005; Te Velde et al., 2002; Tuyttens et al., 2010; Van Huik and Bock, 2007; Vanhonacker et al., 2010; Vanhonacker et al., 2008). However, none of these studies evaluate different entities and different stakeholders relevant for differences in attitudes toward sow husbandry at the same time. Therefore, the first objective of this study was to determine and compare attitudes toward sow husbandry in respect to relevant aspects related to animals, humans and the environment of various stakeholders, including citizens and pig farmers. These attitudes are connected to issues related to sow husbandry, e.g., piglet mortality, castration and use of antibiotics. As attitudes differ between stakeholders it is interesting to know if there are differences between these stakeholders in the acceptance of these issues. Therefore, the second objective of this study was to determine and compare the acceptability of issues related to sow husbandry of various stakeholders.

3.2 Methods

Participants

A questionnaire was distributed via internet to stakeholders of pig husbandry, i.e., citizens, conventional pig farmers, organic pig farmers, pig husbandry advisors and pig veterinarians. These stakeholders were selected because they all are important when it comes to sow husbandry measures. The attitudes of citizens are the reason why the pig sector develops new measures. New measures are implemented by pig farmers. We made a distinction between organic and conventional pig farmers assuming that the two types of farmers have different attitudes toward sow husbandry because of their different farming systems. Pig farmers have close contact with sow husbandry advisors and pig veterinarians. These advisors are expected to influence the development of measures for sow husbandry.

A randomly selected panel of 2,572 Dutch citizens was invited to fill in the questionnaire in October 2011 (CentERdata, Tilburg, the Netherlands). A week after the invitation, the panel received a reminder. In total the panel had two weeks the time to fill in the questionnaire. The questionnaire was open from October until December 2011 for all other stakeholders. These stakeholders were approached in different ways. TOPIGS (a global leader in pig breeding and artificial insemination) provided a list of 2,399 addresses of conventional pig farmers (TOPIGS, Helvoirt, the Netherlands). From this list the addresses of pig farmers with less than 50 sows were excluded. From the remaining list 1,000 randomly selected

addresses received an invitation. Two weeks after the first letter a reminder letter was sent. The 60 organic pig farmers affiliated with the association of organic pig keepers (VBV, Uden, the Netherlands) received an invitation as part of the general electronic newsletter. To the 320 pig veterinarians affiliated with the royal Dutch Society for Veterinary Medicine (KNMvD, Houten, the Netherlands) an invitation for the questionnaire was sent by electronic mail. A reminder was sent by electronic mail three weeks after the initial invitation. The 370 pig husbandry advisors who were member of Agrivaknet (an independent trade union of agricultural specialists, Lettele, the Netherlands) also received an invitation by electronic mail and a reminder after three weeks.

The response rate per stakeholder was as follows:

- Citizens: 1607 of 2572 (62.5%), of which 5 were pig veterinarians and 2 were pig husbandry advisors;
- Conventional pig farmers: 181 of 1000 (18.1%);
- Organic pig farmers: 11 of 60 (18.3%);
- Pig husbandry advisors: 70 of 370 (18.9%);
- Pig veterinarians 66 of 320 (20.6%).

The socio-demographic features of the stakeholders are presented in Table 3.1.

Data collection

To be able to formulate questions for the questionnaire we developed a framework (Figure 3.1). The framework includes aspects that play a role in attitudes toward relevant issues of sow husbandry. Issues that were shown in the media by animal welfare organizations (Society for the protection of animals, Stichting varkens in nood and Wakker dier) from 2009 until 2011 were considered to be relevant. The relevant issues were: piglet mortality, pig housing, scale increase, interventions (castration, tail docking) in piglets, pig euthanasia, sow lifespan, piglet litter size, weaning age of piglets, motherless care of piglets, use of antibiotics in pigs and anesthetics used to sedate pigs. The use of anesthetics was excluded from the framework because it is covered by the castration issue as discussions about this issue predominately focused on the use of anesthetics during the castration process.

Attitudes toward issues of sow husbandry are related to aspects of different entities, i.e., animals (i.e., pigs), humans (both animal keepers and consumers) and the environment. These entities were included in the framework. Per entity, categories and the aspects relevant for attitudes toward issues of sow husbandry, based on literature (Figure 3.1), information from the pig sector and expert knowledge, were added. The issues of sow

husbandry were also added as aspects because people have direct attitudes toward these issues.

Table 3.1 Percentage respondents per category of socio-demographic features for each stakeholder. Stakeholders: citizens (Cit), conventional pig farmers (Con), organic pig farmers (Org), pig farm advisors (Adv), pig veterinarians (Vet).

Socio-demographic feature	Category	Cit	Con	Org	Adv	Vet
Gender:	Male	54.8	95.0	72.7	87.1	86.4
	Female	45.2	5.0	27.3	12.9	13.6
Age:	15-24	3.5	1.1	0.0	7.1	0.0
	25-34	4.6	14.5	18.2	15.7	12.1
	35-44	14.1	32.4	0.0	25.7	18.2
	45-54	19.7	39.1	63.6	40.0	42.4
	55-64	26.6	12.8	18.2	8.6	25.8
	65-older	31.5	0.0	0.0	2.9	1.5
Education:	Primary school	4.8	0.0	0.0	0.0	0.0
	Secondary school (low)	27.3	4.5	9.1	2.9	0.0
	Secondary school (high)	12.3	6.1	0.0	2.9	0.0
	Vocational	15.9	58.7	63.6	15.7	0.0
	BSc	26.8	28.5	27.3	55.7	0.0
	MSc	12.8	2.2	0.0	22.9	100.0
Religious:	Yes	28.1	36.5	9.1	32.9	25.8
	No	50.6	32.0	72.7	32.9	56.1
	Little	21.3	31.5	18.2	34.3	18.2
Pets:	Yes	41.7	84.4	90.9	71.4	90.6
	No	58.3	15.6	9.1	28.6	9.4
Childhood residence:	Randstad	25.6	3.9	0.0	8.6	13.6
	Big city	13.1	1.1	10.0	4.3	13.6
	Small city	16.8	2.2	10.0	5.7	6.1
	Big village	16.4	18.3	10.0	24.3	25.8
	Small village	28.1	74.4	70.0	57.1	40.9
Urban character residence:	Extremely urban (>2500*)	14.0	1.1	0.0	8.7	7.8
	Highly urban (1500-2500*)	24.8	2.9	9.1	8.7	6.3
	Urban (1000-1500*)	21.4	10.3	9.1	21.7	17.2
	Moderately urban (500-1000*)	22.0	21.7	9.1	24.6	14.1
	Not urban (<500*)	17.8	64.0	72.7	36.2	54.7

* Number of residents per square kilometer

Based on the framework, we developed a questionnaire. In the questionnaire as little information as possible was given to minimize influencing respondents attitudes as information can have an effect on attitudes. Because attitudes cannot be measured directly, in the first part of the questionnaire respondents could give additional care (AC)

levels, i.e., the degree of extra attention that was found necessary compared to the current situation, to each aspect mentioned in Figure 3.1. It was assumed that AC levels can represent attitudes in that higher AC levels indicate more negative attitudes. AC levels could be indicated on a Likert scale of 1 (no AC necessary) to 10 (maximal AC necessary).

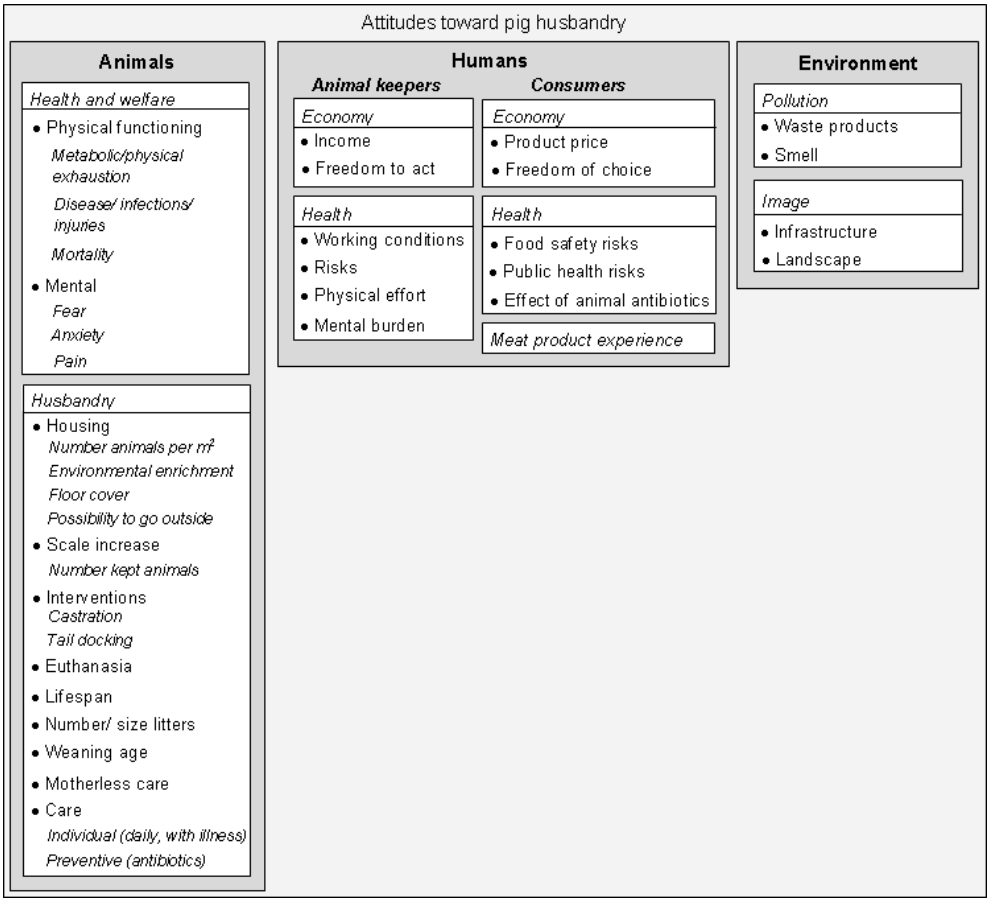

Figure 3.1 Framework for the assessment of attitudes toward sow husbandry. Per entity of sow husbandry (i.e., animals, humans and the environment), categories with aspects that play a role in attitudes toward sow husbandry are presented.
Based on information from the pig sector, expert knowledge and literature: Barnett et al., 2001; Beekman et al., 2002; Boogaard et al., 2011 a; Boogaard et al., 2011 b; Cohen, 2010 a; Cohen et al., 2012; Driessen, 2010; Fraser, 1999; Frederiksen et al., 2010; Harper and Henson, 2001; Huber-Eicher and Spring, 2008; Kanis et al., 2003; Krystallis et al., 2009; Lagerkvist et al., 2006; Marchant-Forde, 2009; McGlone, 2001; Mepham, 2000; Meuwissen and van der Lans, 2005; Michalopoulos et al., 2008; Millman, 2011; Ngapo et al., 2003; Petit and van der Werf, 2003; Te Velde et al., 2002b; Tuyttens et al., 2010a; Vanhonacker et al., 2010 b; Vanhonacker et al., 2010 a; Vanhonacker et al., 2008a; Verbeke and Viaene, 1999; Verdoes and Swinkels, 2003; Von Essen and McCurdy, 1998; Webster, 2001

The second part of the questionnaire included a question about the acceptability of issues related to sow husbandry, i.e., piglet mortality, weaning age of piglets, castration of piglets, tail docking of piglets, interventions (castration/ tail docking) without sedation, interventions (castration/ tail docking) with sedation, housing of pigs indoor, the use of farrowing pens, euthanize sick pigs, allow the farmer to decide when a pig should be euthanized, lifespan of sows, and the effect of the use of antibiotics on public health. Respondents could indicate whether they found these issues acceptable, not acceptable or that they had no judgment. In the last part of the questionnaire, respondents were asked for their socio-demographic features, i.e., gender, age, level of education, religious (yes, no or a little), pets (yes or no), type of meat eaten, urban character of residence, and size of childhood residence. The full questionnaire is available by contacting the first author of this paper.

Data Analysis

Before the statistical analyses were performed, the AC levels were decreased from a ten-point Likert scale to a five-point Likert scale (1: no AC necessary, 2: little AC necessary, 3: temperate AC necessary, 4: strong AC necessary and 5: maximal AC necessary); levels 1 and 2 became level 1, levels 3 and 4 became level 2, levels 5 and 6 became level 3, levels 7 and 8 became level 4 and levels 9 and 10 became level 5).

Descriptive statistical analyses were carried out to identify AC levels assigned to aspects related to sow husbandry of citizens, conventional pig farmers, organic pig farmers, pig husbandry advisors and pig veterinarians. The probability that respondents from a certain stakeholder gave higher or lower AC levels than respondents in the other clusters was calculated with ordered multinomial logistic regression. In this regression corrections were made for socio-demographic features (Table 3.1) to ensure that probabilities were not affected by these features. Descriptive statistical analyses were carried out to identify acceptability of issues with regard to sow husbandry of citizens, conventional pig farmers, organic pig farmers, pig husbandry advisors and pig veterinarians. To analyze whether respondents in the one stakeholder had a higher or lower probability to choose ‘no’ for the acceptability of issues than respondents in the other stakeholders, binary logistic regression was performed.

For statistical analyses IBM SPSS Statistics 19 (IBM Corporation, New York, United States) and EViews6 (IHS EViews, Irvine, United States) were used. In SPSS descriptive statistical analysis was performed, and in EViews all other analyses were carried out.

3.3 Results

The different stakeholders, i.e., citizens, conventional pig farmers, organic pig farmers, pig veterinarians and pig husbandry advisors assigned different additional care (AC) levels to aspects of sow husbandry (Table 3.2). The differences between stakeholders were calculated with a correction for socio-demographic features (Table 3.1), which means that these differences are not the result of differences in socio-demographic features.
The highest AC levels (≥3.3 on a five-point scale) were given by citizens and organic pig farmers. Although both stakeholders gave AC levels above average, there was a probability that organic pig farmers gave higher AC levels than citizens for some of the aspects, e.g., tail docking, litter size and weaning age. Citizens gave the highest AC levels (≥4.0) to the possibility for animals to go outside, the effect of the use of antibiotics on both animals and humans, food safety risks, public health risks and environmental waste. Compared to citizens, conventional pig farmers gave to most aspects lower AC levels but gave higher AC levels (≥3.7) to enough income, freedom to act and mental burden for the animal keeper, and price of the product and the experience of meat products for consumers. The probability that pig husbandry advisors gave different AC levels than conventional pig farmers was only significant for four aspects, i.e., quality/quantity feed, number of kept animals, motherless care and image landscape. The probability that pig veterinarians gave different AC levels than the other stakeholders was significant for most aspects related to animals. These AC levels were the most different from conventional pig farmers and pig husbandry advisors, in which pig veterinarians gave higher AC levels, and the least different from citizens and organic pig farmers, in which pig veterinarians gave lower AC levels except for time euthanasia. With regard to humans and the environment, pig veterinarians more often had the probability to give AC levels that differed from those of citizens than from those of the other stakeholders.

Acceptability of issues related to sow husbandry

Respondents could indicate if they found issues related to sow husbandry acceptable or not, or if they had no judgment. For most issues, the acceptability differed between stakeholders (Table 3.3). The majority of the respondents (>58%) from all stakeholders did find interventions with sedation and euthanizing sick animals acceptable. Therefore, these issues were excluded from the table. Table 3.3 shows that more than one fifth of the citizens had no judgment for a number of issues, i.e., piglet mortality, weaning age,

Table 3.2 Average additional care (AC) level, i.e., the degree of extra attention that was found necessary compared to the current situation, on a five-point scale per aspect of sow husbandry per stakeholder. Stakeholders: citizens (Cit), conventional pig farmers (Con), organic pig farmers (Org), pig farm advisors (Adv), pig veterinarians (Vet).

Entity	Aspect	Average AC level				
		Cit	*Org*	*Con*	*Adv*	*Vet*
Animal	*Metabolic/physical exhaustion*	3.4[a]	3.5[a]	2.7[b,c]	2.3[b,d]	3.4[a]
	Disease/infection/injuries	3.8[a]	3.5	3.0[b]	2.8[b,c]	3.3[d]
	Mortality	3.6[a]	3.3	2.9[b,c]	2.8[b,c]	3.2[d]
	Fear/anxiety	3.8[a]	4.1[a]	2.6[b,c]	2.7[b,c]	3.4[b,d]
	Pain	3.9[a]	3.5[a]	2.6[b]	2.6[b]	3.5[a]
	Number of animals per m2	3.9[a]	4.0[a]	2.3[b,c]	2.1[b,c]	3.2[b,d]
	Environmental enrichment	3.6[a]	3.9[a]	2.5[b,c]	2.4[b,c]	3.2[b,d]
	Floor cover	3.8[a]	3.7[c]	2.3[b,d]	2.1[b,d]	3.2[b,c]
	Possibility to go outside	4.0[a]	3.6[a]	1.5[b]	1.4[b,c]	1.9[b,d]
	Number of kept animals	3.8[a]	4.1[a]	2.3[b,c]	2.0[b,d]	2.5[b,c]
	Castration	3.6[a]	3.9[a]	2.7[b,c]	2.4[b,c]	3.4[d]
	Tail docking	3.6[a]	4.3[b,c]	2.2[b,d,e]	2.2[b,d,e]	3.1[b,d,f]
	Time euthanasia	3.6[a]	4.0[b,c]	2.9[b,d]	3.1[d]	4.0[b,c]
	Lifespan sow	3.7[a]	3.5[a]	2.6[b]	2.4[b]	3.0[a]
	Number of litters per sow	3.6[a]	4.0[a]	2.3[b]	2.1[b]	2.1[b]
	Litter size	3.5[a]	4.1[b,c]	2.4[b,d]	2.2[b,d]	2.3[b,d]
	Weaning age	3.6[a]	4.5[b,c]	2.3[b,d]	2.3[b,d]	3.2[a,d]
	Motherless care	3.7[a]	4.0[a]	2.7[b,c]	2.3[b,d]	3.1[c]
	Care for individual animal	3.8[a]	4.2[b,c]	2.5[b,d]	2.7[b,d]	3.4[c]
	Use of antibiotics (animal)	4.2[a]	4.5[a]	3.2[b]	3.4[b]	3.8[b]
Animal keeper	*Enough income*	3.6[a]	4.3[b]	4.5[b]	4.4[b]	4.3[b]
	Freedom to act	3.3[a]	3.7[c]	3.7[b,c]	3.4[b,c]	2.7[b,d]
	Working conditions	3.5	3.7	3.4	3.1	3.4
	Health risks	3.8[a]	3.8[a]	3.3[b]	3.2[b]	3.4
	Physical burden	3.5	3.7	3.4	3.1	3.2
	Mental burden	3.5[a]	4.1[b]	3.8[b]	3.8[b]	3.7[b]
Consumer	*Price product*	3.3[a]	3.9[b]	4.1[b]	3.9[b]	3.8[b]
	Freedom of choice	3.4[a]	3.9[b]	3.2[a]	3.2[a]	2.9[a]
	Food safety risks	4.0[a]	3.7[a]	2.8[b]	2.6[b]	2.7[b]
	Public health risks	4.0[a]	3.8[a]	2.8[b]	2.7[b]	2.8[b]
	Use of antibiotics (human)	4.2[a]	3.9[a]	3.2[b]	3.4[b]	3.5[b]
	Experience meat products	3.4[a]	4.5[b,c]	3.7[b,d]	3.9[b]	3.5[b,d]
Environment	*Environmental waste*	4.0[a]	3.3[c]	2.5[b,d,e]	2.5[b,e]	3.0[b,f]
	Smell	3.6[a]	3.5[c]	2.6[b,d]	2.5[b,d]	2.9[b,c]
	Change in infrastructure	3.7[a]	3.3[c]	2.5[b,d]	2.5[b,d]	2.8[b]
	Image landscape	3.6[a]	3.7[a]	2.7[b,c]	2.4[b,d]	2.8[b,c]

[a, b] The probability that respondents in the stakeholder group with 'a' gave higher/lower AC levels than respondents in the stakeholder group with 'b' was significant ($P<0.05$) for that particular aspect.

[c, d] The probability that respondents in the stakeholder group with 'c' gave higher/lower AC levels than respondents in the stakeholder group with 'd' was significant ($P<0.05$) for that particular aspect.

[e, f] The probability that respondents in the stakeholder group with 'e' gave higher/lower AC levels than respondents in the stakeholder group with 'f' was significant ($P<0.05$) for that particular aspect.

Table 3.3 Percentage of respondents of stakeholders per answer option for the acceptability per issue of pig husbandry. Answer options: acceptable (Yes), not acceptable (No), no judgment (NJ). Stakeholders: citizens (Cit), conventional pig farmers (Con), organic pig farmers (Org), pig farm advisors (Adv), pig veterinarians (Vet).

Issue		Percentage respondents				
		Cit	*Org*	*Con*	*Adv*	*Vet*
Piglet mortality	Yes	15.3	72.7	82.3	72.9	65.2
	No	20.7[a]	18.2	13.8[b,c]	22.8	31.8[b,d]
	NJ	64.0	9.1	3.9	2.9	3.0
Weaning age	Yes	25.1	36.4	97.2	87.2	69.7
	No	21.6[a]	63.6[b,c]	2.8[b,d,e]	11.4[b,d,f]	28.8[a]
	NJ	53.3	0.0	0.0	1.4	1.5
Castration	Yes	45.4	72.7	61.9	65.7	44.0
	No	31.0[a]	18.2[a]	32.0[a]	27.2[a]	54.5[b]
	NJ	23.6	9.1	6.1	7.1	1.5
Tail docking	Yes	20.4	9.1	92.2	84.3	59.1
	No	60.3[a]	81.8[a]	3.9[b,c]	5.7[b,c]	36.4[b,d]
	NJ	19.3	9.1	3.9	10.0	4.5
Interventions without sedation	Yes	4.7	18.2	77.3	64.3	21.2
	No	82.5[a]	81.8[c]	13.3[b,d,e]	25.7[b,d,f]	72.7[b,c]
	NJ	12.8	0.0	8.8	10.0	6.1
Housing indoor	Yes	16.6	27.3	98.3	98.6	95.5
	No	68.5[a]	54.5[a]	0.6[b]	1.4[b]	3.0[b]
	NJ	14.9	18.2	1.1	0.0	1.5
Farrowing pens	Yes	40.6	27.3	97.8	94.3	84.8
	No	33.8[a]	54.5[a]	1.1[b,c]	1.4[b]	10.7[b,d]
	NJ	25.6	18.2	1.1	4.3	4.5
Pig farmer decides when to euthanize	Yes	50.0	90.9	98.3	92.9	59.1
	No	28.3[a]	9.1	1.1[b]	5.7[b]	31.8[a]
	NJ	21.7	0.0	0.6	1.4	9.1
Lifespan sow	Yes	24.3	27.3	90.5	82.9	78.8
	No	14.9[a]	27.3[a]	7.2[b]	12.8	18.2[a]
	NJ	60.8	45.4	1.7	4.3	3.0
Effect antibiotics on public health	Yes	8.5	9.1	45.9	30.0	22.7
	No	63.7[a]	63.6	35.9[b]	58.6[a]	65.2[a]
	NJ	27.8	27.3	17.1	11.4	12.1

[a, b] The probability that respondents in the stakeholder group with 'a' chose for the answer option 'no' was significantly (P<0.05) higher/lower compared to respondents in the stakeholder group with 'b' for that particular issue.

[c, d] The probability that respondents in the stakeholder group with 'c' chose for the answer option 'no' was significantly (P<0.05) higher/lower compared to respondents in the stakeholder group with 'd' for that particular issue.

[e, f] The probability that respondents in the stakeholder group with 'e' chose for the answer option 'no' was significantly (P<0.05) higher/lower compared to respondents in the stakeholder group with 'f' for that particular issue.

castration of piglets, farrowing pens, pig farmer decides when to euthanize, lifespan sow and the effect of antibiotics on public health.

More than half of the citizens had no judgment for piglet mortality, weaning age and lifespan sow. Weaning age was the only issue for which the probability that citizens scored 'no' for acceptability was different from organic pig farmers. Most organic pig farmers (>54%) and citizens (>60%) found tail docking, interventions without sedation, housing animals indoor and the effect of antibiotics on human health not acceptable. For tail docking and housing animals indoor, citizens had a higher probability to find these issues not acceptable than conventional pig farmers, pig veterinarians and pig husbandry advisors. For interventions without sedation, citizens had a higher probability to find this issue not acceptable than conventional pig farmers and pig husbandry advisors. Pig veterinarians also found interventions without sedation unacceptable, but had a lower probability to find this issue unacceptable than citizens. Of the conventional pig farmers, less than half of the respondents found the effect of antibiotics on public health not acceptable. This was in contrast to the other stakeholders of which more than 58% of the respondents found the effect of antibiotics on public health not acceptable.

3.4 Discussion

The present study is the first study that compared attitudes toward different entities associated with sow husbandry, i.e., animals, humans and environment, of different stakeholders. The stakeholders that we included were citizens, conventional pig farmers, organic pig farmers, farm advisors and pig veterinarians. These stakeholders were selected because they are decisive for the pig sector and it has been shown that attitudes toward animal husbandry of these stakeholders differ (Te Velde et al., 2002; Tuyttens et al., 2010; Van Huik and Bock, 2007; Vanhonacker et al., 2008). The questionnaire was distributed to members of the appointed stakeholders in different ways, i.e., by electronic mail, in an electronic newsletter or by a written letter. Although these different approaches are known to have an effect on response rate, they were chosen to get the highest response because approach options were limited. With limited access to stakeholder databases the applied approaches were the best achievable to get a response. Despite the different approaches, the response rate for all stakeholders except citizens was about equal (18 – 22%). The response rate of citizens (62.5%) was higher than that of the other stakeholders because they were in a panel of citizens representative for the Netherlands who indicated to be

willing to participate in these types of research, while the other stakeholders were approached unannounced.
The stakeholders differed in socio-demographic features (Table 1). We know that these features can have an effect on attitudes toward animal husbandry (Bergstra et al., 2014; Boogaard et al., 2006; Frederiksen et al., 2010; Herzog, 2007; Knight et al., 2004; María, 2006; Prickett et al., 2010; Tuyttens et al., 2010; Vanhonacker et al., 2010). Since in the present study we were only interested in differences between stakeholders, in the statistical modelling we corrected for differences in socio-demographic features.

The attitudes of the different stakeholders toward sow husbandry with respect to aspects of animals, humans and the environment were expressed in additional care (AC) levels, , i.e., extra attention that was found necessary compared to the current situation. The higher the AC levels (on a five-point scale), the more negative the attitude. Attitudes were also reflected in the acceptability of issues related to sow husbandry, i.e. tail docking, housing animals indoor and the effect of the use of antibiotics on public health. When an issue was is not accepted it is most likely that attitudes toward that issue are negative.
Based on attitudes toward sow husbandry and the acceptability of issues related to sow husbandry, the studied stakeholders could be divided into three distinctive groups. The first group consists of citizens and organic pig farmers. This group showed negative attitudes toward sow husbandry with respect to all defined aspects and found several issues of sow husbandry, i.e., tail docking, interventions without sedation, housing animals indoor and the effect of the use of antibiotics on public health, not acceptable. The second group consists of conventional pig farmers and pig husbandry advisors. This group showed negative attitudes toward sow husbandry with respect to only economic aspects and found all defined issues of sow husbandry, except the effect of the use of antibiotics on public health, acceptable. The third group consists of pig veterinarians. This group showed negative attitudes toward sow husbandry with respect to specific aspects of sow husbandry, e.g., time euthanasia and enough income for the animal keeper, and found specific issues of sow husbandry, i.e., castration, interventions without sedation and the effect of the use of antibiotics on public health, not acceptable.

The differences in attitudes toward sow husbandry and in acceptability of issues of sow husbandry are influenced by people's interests (Boogaard et al., 2006). Citizens interest in animal welfare and healthy meat (Te Velde et al., 2002) are reflected in the negative attitudes (AC levels ≥ 3.4) toward all defined aspects related to the animal and to human health, and in not accepting issues as housing animals indoor and the effect of the use of

antibiotics on public health. Citizens' attitudes toward sow husbandry with respect to aspects of the environment were also negative (AC levels ≥ 3.6), indicating that they also have an interest in the environment. Organic pig farmers could be placed in the same group as citizens. Hence, organic pig farmers probably share the same interests as citizens. Different from citizens, organic pig farmers also seem to have a high interest in economics as they showed strong negative attitudes toward sow husbandry with respect to the income of the animal keeper and the price of the product for the consumer (AC levels ≥ 3.8). The economic interest was also shown by conventional pig farmers and pig husbandry advisors. Pig farmers in general have an interest in economics (Bracke et al., 2005; Te Velde et al., 2002). That this interest is shared by both conventional and organic pig farmers is obvious because they both depend on economics in their business. However, conventional pig farmers and pig husbandry advisors seem to be predominately interested in economics while organic pig farmers seem to be interested in aspects related to animals, human health and the environment as well. These different interests may partly be explained by how they define animal welfare. Research showed that in several countries within the European Union, including the Netherlands, conventional pig farmers defined animal welfare on the basis of physical health and production level of the animals (Bock et al., 2007b). In contrast, organic pig farmers defined animal welfare on the basis of the possibility for the animals to perform natural behavior and were focused on freedom and comfort for the animals (Bock et al., 2007b). Freedom and comfort of the animals include both physical and mental health. The mental stage of animals is positively influenced when animals have the possibility to perform natural behavior (Bracke and Hopster, 2006). Citizens also consider both the physical and mental stage of the animals in defining animal welfare (Te Velde et al., 2002). This may explain why results of the present study could place citizens and organic pig farmers in the same group. This group reflects that they include the mental stage of animals in their negative attitude toward sow husbandry with respect to aspects of the animal, e.g. fear and anxiety, the number of kept animals and animals not having the possibility to go outside, and in not accepting certain issues of sow husbandry, e.g., housing animals indoor. Being outside is part of an animals' natural life and involves certain natural behaviors, such as rooting. Those behaviors are needed by an animal for 'good' welfare (Boogaard et al., 2006) and contribute to a certain mental stage. Citizens and organic pig farmers believe that this mental stage can only be reached when animals have the possibility to go outside. Conventional pig farmers and pig husbandry advisors found the possibility for animals to go outside less important and found it acceptable to house animals indoor. Conventional pig farmers and pig husbandry advisors probably do not consider the mental stage of animals or does not consider this mental

stage essential for the welfare of pigs. If they do consider the mental stage essential, they may believe that the animal's mental health can also be reached when animals are kept indoor. Pig veterinarians seem to have specific interests that partly relate to interests of citizens and organic pig farmers and partly to interests of conventional pig farmers and pig husbandry advisors. Like the latter two stakeholders, pig veterinarians seem to be interested in economics. Besides these interests, pig veterinarians seem to be, like citizens and organic pig farmers, interested in aspects related to the animal. However, pig veterinarians are only interested in specific aspects of the animal, such as euthanizing animals or the effect of the use of antibiotics on animals.

These results suggest that different groups judge sow husbandry from different perspectives. Pig veterinarians judge pig welfare based on physiological and productive characteristics. In their judgment of animal welfare, pig veterinarians might consider and weigh their attitudes with regard to aspects related to the animal keeper as well. Because animal keepers have limitations in their production system, pig veterinarians may first seek for technical solutions to solve animal welfare problems, such as environmental enrichment for undesired pig behavior. Conventional pig farmers and pig husbandry advisors judge pig husbandry from an entrepreneurial point of view. They consider and weigh the effect of different factors on their business. In their judgment of measures for sow husbandry, they consider and weigh their attitudes toward sow husbandry based on their interests and legal rules they have to obey. As their interest in economics is obvious, aspects related to economics will often outweigh other aspects in attitudes toward sow husbandry. Citizens and organic pig farmers consider each aspect of sow husbandry separately. All aspects of sow husbandry will, therefore, have a value on its own in the judgment of sow husbandry, based on interests, emotional experiences and knowledge (Boogaard et al., 2006; Knight and Barnett, 2008; Knight et al., 2004).

Because the stakeholders within each of the three defined groups have the same perspectives, they understand each other. This understanding results in trust. Between groups, the perspectives are different what results in a lack of understanding and trust. The lack of understanding between citizens and the sector is reflected in citizens' attitudes toward measures developed by the sector, which are mainly people from the second group. Measures are developed to solve issues of sow husbandry. In most cases, technical solutions will be introduced to improve the issue. For example, the measure 'motherless care' that was described in the introduction, indeed results in a decrease in piglet mortality and thus improves the issue. However, citizens seem to be dissatisfied with this measure because piglets will be raised without a mother. This indicates that the measure does not

improve citizens' attitudes but rather shifts the negative attitudes from one aspect to another.

In the acceptance of issues, attitudes related to different aspects play a role. Citizens will consider every aspect separately without weighing them with respect to each other. As a consequence, citizens' negative attitudes toward sow husbandry will shift from one aspect to the other. This means that the implementation of a measure with regard to that issue will not change citizens' overall judgment of sow husbandry. The measure developers, e.g. pig farmer, pig husbandry advisors and pig veterinarians, do weigh the different aspects of sow husbandry in the development of the measure and believe that they deliver a balanced and optimal solution for the problem. They do not understand that citizens look at each aspect separately and that citizens do not understand the weighing of aspects. The sector should indulge in the perspective of citizens to be able to understand their attitudes. At this point the sector has limited insight in the perspective and attitudes of citizens. To be able to get an idea about citizens attitudes it is necessary for the sector to get informed about citizens' attitudes toward sow husbandry with respect to relevant aspects of pig husbandry in the development of measures. In order to get understanding and trust for sow husbandry measures from citizens, it is important to communicate with citizens. In general, citizens have a lack of knowledge when it comes to animal husbandry (Boogaard et al., 2006; Kendall et al., 2006; Knight and Barnett, 2008). Conventional pig husbandry systems have developed into closed systems what makes it even harder for citizens to get informed about what the farming system implies for animals, humans and the environment. The lack of knowledge is reflected in that at least one fifth of citizens had no judgment about the acceptability of several issues of pig husbandry, i.e., piglet mortality, weaning age, castration of piglets, farrowing pens, pig farmer decides when to euthanize, lifespan of the sow and the effect of the use of antibiotics on human health. That citizens do not have a judgment because of lack of knowledge indicates that citizens base their judgment on information they receive. This means that providing information about sow husbandry can influence citizens' judgment of sow husbandry. Therefore, it is recommended to communicate with citizens about the steps that are and/or will be taken and why these steps are and/or will be taken in the development of these measures. In this communication it is important that the sector explains how they weighed the different aspects and why, and that they recognize and share the additional problems. For example, with the measure 'motherless care', the sector should communicate to citizens that they are aware of the fact that piglets are raised without a mother and that such a practice is not optimal considering natural behavior. By explaining the consequences for the involved piglets when they stay with their mother, i.e., malnutrition and eventually death, and the

positive effects of the measure, the sector can stimulate citizens to weigh the different aspects of sow husbandry relative to each other in their attitudes toward sow husbandry.
In conclusion, stakeholders of sow husbandry have different attitudes toward sow husbandry. Three distinctive groups could be defined when it comes to attitudes toward sow husbandry. The group of citizens and organic pig farmers showed negative attitudes toward sow husbandry with respect to all defined aspects of sow husbandry, the group of conventional pig farmers and pig husbandry advisors only showed negative attitudes toward sow husbandry with respect to only economic aspects and the group of pig veterinarians showed negative attitudes toward sow husbandry with respect to specific aspects. The differences in attitudes toward sow husbandry indicate that the different groups judge sow husbandry from a different perspective. These different perspectives result in a lack of understanding and trust between the different groups. To be able to get understanding and trust, communication between these groups is essential.

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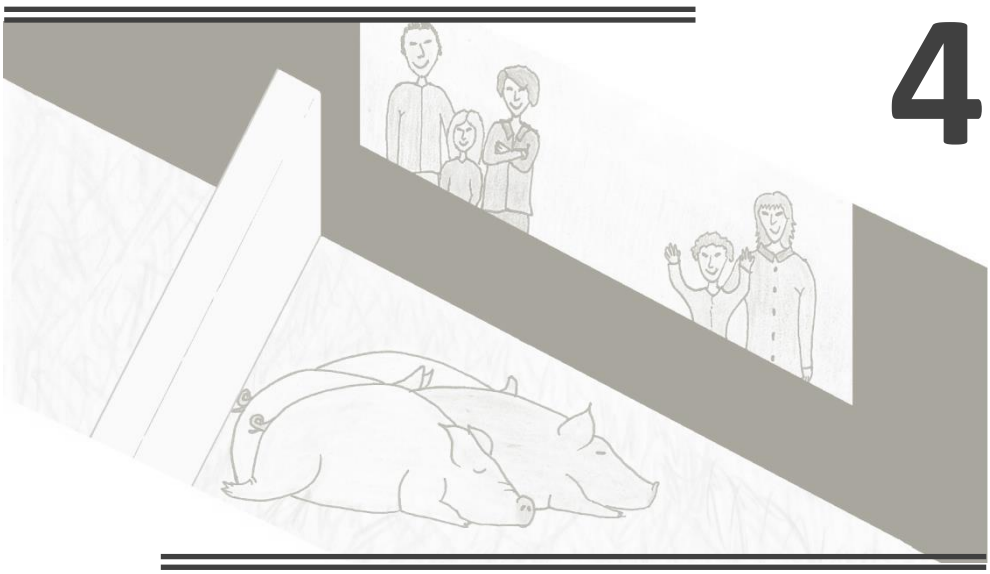

4

Basic values and attitudes toward sow husbandry

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Under review

Abstract

Attitudes toward sow husbandry of citizens and conventional pig farmers are different. We hypothesized that these attitudes cannot one-on-one be predicted by basic (i.e., ethical) values of these groups. Furthermore, we were interested in how basic values can be useful in bridging the gap between attitudes toward sow husbandry of citizens and pig farmers. Based on a questionnaire, results show that basic values cannot be related one-on-one to attitudes toward sow husbandry. The valuation of most basic values was shared by pig farmers and citizens as one group. Comparing pig farmers and four clusters of citizens, that were clustered based on additional care (AC) they found necessary for different aspects of sow husbandry, showed that the high-AC and max-AC cluster often disagreed on the valuation of basic values with pig farmers but that the moderate-AC and the no-AC cluster did. The moderate-AC clusters valued the basic value 'living conditions should be natural' similar to the high-AC and max-AC cluster. Weighing these basic values is based on the interpretation of naturalness, which differs between citizens and pig farmers. When pig farmers learn to understand how the interpretation and weighing of the moral value 'living conditions should be natural' contributes to the moral reasoning of the moderate-AC cluster, this can be used in the development of new systems and measures for sow husbandry to improve animal welfare and in their communication to society. This may bridge the gap in attitudes toward sow husbandry between pig farmers and citizens.

Keywords

Attitudes, basic values, naturalness, sow husbandry

4.1 Introduction

In the last decades, societal concerns about animal husbandry systems have increased and became more prominent (Barnett et al., 2001; Bergstra et al., 2014a; De Barcellos et al., 2012; Krystallis et al., 2009; María, 2006; Mench, 2008; Meuwissen and van der Lans, 2005; Ngapo et al., 2003; Schröder and McEachern, 2004). In this paper we will focus on sow husbandry where, for example, there are animal-related concerns about castration and tail docking without anesthesia, pig housing (e.g., surface, social contact and environmental enrichment) and the use of antibiotics in pigs (Barnett et al., 2001; Bergstra et al., 2014a; Boogaard et al., 2011 b; Frederiksen et al., 2010; Marchant-Forde, 2009; Millman, 2011). There are also concerns about human health and the environmental consequences with regard to animal husbandry (Bergstra et al., 2014a; Brom, 2000; Harper and Makatouni, 2002; Harper and Henson, 2001; McGlone, 2001; Verbeke and Viaene, 2000; Webster, 2001). Most of these societal concerns arise from negative attitudes of citizens toward sow husbandry. Between citizens and other stakeholders, major differences in these attitudes and attitudes toward sow husbandry in general have been reported (Bergstra et al., 2014b; Bock and van Huik, 2007a; Lassen et al., 2006; Te Velde et al., 2002; Tuyttens et al., 2010; Van Huik and Bock, 2007; Vanhonacker et al., 2008). The focus of this paper will be on two Dutch stakeholder groups, i.e., citizens and conventional pig farmers, because these groups play a crucial role in societal concerns about sow husbandry. In the remainder of this paper, pig farmer stands for conventional pig farmer.

Attitudes in public debates originate in basic values (Rokeach, 1968-1969). Basic values can be defined as ethical values that, depending on culture, science, education, social background and legislation, each individual person develops during life (Fraser, 1999). Several studies have included basic values of farmers and citizens (Cohen et al., 2010 b, 2012; Te Velde et al., 2002; Tuyttens et al., 2010; Vanhonacker et al., 2008). However, most of these studies did not focus on a specific context. In the context of a specific animal husbandry, basic values have an influence on the general acceptance of this animal practice (Fraser, 2008). For example, modern dairy farm practices are more accepted by people who opt for the basic value that humans are superior to animals than by people who opt for the basic value that humans and animals are equivalent (Boogaard et al., 2011 a). Also the basic value that farm animals are being sentient has an influence on the acceptance of animal husbandry practices (Duncan, 2006; Knight et al., 2004). When a farm animal is considered to be sentient, the effect of animal husbandry practices on pain and/ or distress of the

animal has to be justified before the animal husbandry practice can be accepted (Knight et al., 2004).

Basic values underlying attitudes could, in principle, open the possibility to predict the attitudes of different groups when their basic values are known. Knowledge of this relation may enable the possibility to use it as a diagnostic tool to find out if a certain difference in attitudes is caused by a difference in basic values or a difference in weighting or interpretation of the same basic values. With regard to a certain context all individual basic values will be weighted relative to each other in order to form attitudes (Cohen, 2010a). This could lead to a situation in which people with the same set of basic values could develop different attitudes. In such a situation it becomes difficult to predict attitudes based on information about basic values. Cohen et al. (2010a, 2012) concluded that moral values can only predict the judgment of culling healthy animals in the course of a disease epidemic to a certain extent, i.e. when moral values with regard to animals were considered important this person was most likely against the culling of healthy animals. In this paper we will try to generalize the findings of Cohen et al. (2010a, 2012) to Dutch sow husbandry as a whole by testing the hypothesis that basic values of citizens and pig farmers cannot predict one-to-one the attitudes toward sow husbandry of these groups. Nevertheless, it is still important to know if a set of basic values of citizens and pig farmers is more or less the same in order to understand how these basic values are being weighted and which basic values are considered most important. Knowing which basic values of citizens and pig farmers are more or less shared can help pig farmers understand which basic values influence the difference in weighing of the same set of basic values in forming attitudes toward sow husbandry of these two groups. Learning different ways to weigh the same set of basic values offers better possibilities to bridge the gap between the different attitudes toward sow husbandry of citizens and pig farmers. Hereby, it is interesting to shift the focus from citizens as a single group to the focus on different groups of citizens. For groups of citizens we focus on the study of Bergstra et al. (2014a). In their study, Dutch citizens were asked to give a level of additional care (AC), i.e. the degree of extra attention compared to the current situation they found necessary, for different aspects of entities, i.e., animals, humans and the environment, related to sow husbandry. Based on these AC levels, citizens were divided into four clusters (Table 4.1). The two smallest clusters were the most extreme; the no-AC cluster (7% of respondents) found no AC necessary for the aspects of sow husbandry and the max-AC cluster (14% of respondents) found the most AC necessary compared to the other clusters. The high-AC cluster and the moderate-AC cluster were in between the former two cluster in terms of AC levels, with the high-AC cluster having higher AC levels than the moderate-AC cluster (Table 4.1).

Table 4.1 The average additional care (AC) levels, i.e., the degree of extra attention that was found necessary compared to the current situation, on a five-point scale (1: no AC necessary, 5: maximal AC necessary) of clusters of citizens (Cl; based on AC levels) and pig farmers (Pf).

Entity	Aspect	Cl1*	Cl2	Cl3	Cl4	Pf
Animals	*Quality/quantity feed*	3.7	3.0	4.5	1.7	2.7
	Rate sickness/infection/injury	4.2	3.3	4.8	2.1	3.0
	Mortality	4.1	3.1	4.6	1.9	2.9
	Fear/anxiety	4.3	3.3	4.8	2.1	2.6
	Pain	4.4	3.3	4.8	2.0	2.6
	Number of kept animals	4.4	3.4	4.7	1.9	2.3
	Environmental enrichment	4.0	3.1	4.5	1.8	2.5
	Number of animals per m2	4.4	3.4	4.8	2.0	2.3
	Floor cover	4.3	3.3	4.8	2.0	2.3
	Possibility to go outside	4.5	3.5	4.8	2.1	1.5
	Tail docking	4.2	3.1	4.7	1.7	2.2
	Castration	4.2	3.0	4.7	1.7	2.7
	Time euthanasia	4.1	3.1	4.7	1.5	2.9
	Lifespan sow	4.2	3.1	4.8	1.6	2.6
	Number of litters per sow	4.1	3.1	4.8	1.7	2.3
	Litter size	4.0	3.0	4.7	1.6	2.4
	Weaning age	4.1	3.0	4.7	1.6	2.3
	Motherless care	4.3	3.1	4.8	1.6	2.7
	Care for individual animal	4.3	3.2	4.9	1.6	2.5
	Use of antibiotics (animal)	4.5	3.7	4.9	3.0	3.2
Animal keepers	*Enough income*	3.5	3.4	4.5	3.1	4.5
	Freedom to act	3.2	3.2	4.1	2.7	3.7
	Working conditions	3.5	3.3	4.6	2.5	3.4
	Health risks	3.9	3.5	4.9	2.6	3.3
	Physical burden	3.6	3.3	4.7	2.4	3.4
	Mental burden	3.5	3.3	4.7	2.5	3.8
Consumers	*Price product*	3.3	3.2	4.4	2.3	4.1
	Freedom of choice	3.4	3.1	4.4	2.5	3.2
	Food safety risks	4.2	3.6	4.9	2.7	2.8
	Public health risks	4.3	3.7	5.0	2.8	2.8
	Use of antibiotics (human)	4.4	3.8	5.0	3.2	3.2
	Experience meat products	3.5	3.1	4.6	2.3	3.7
Environment	*Environmental waste*	4.3	3.7	4.8	2.9	2.5
	Smell	3.8	3.6	4.5	2.5	2.6
	Change in infrastructure	4.0	3.3	4.6	2.5	2.5
	Image landscape	3.8	3.2	4.5	2.6	2.7

* Cl1: high-AC cluster (n=645), Cl2: moderate-AC cluster (n=623), Cl3: Max-AC cluster (n=225), Cl4: no-AC cluster (n=114), Pf: pig farmer (n=181).

The AC levels of pig farmers were also determined by Bergstra (2014a; Table 4.1). Results clearly show the differences in attitudes toward sow husbandry of the different clusters of citizens and pig farmers.
Given the differences between citizens and pig farmers in attitudes toward sow husbandry, the main question of this paper is whether these groups also valuate basic values in relation to sow husbandry differently. If basic values are valuated differently, it can be important to learn which basic values are more shared by citizens and pig farmers than others. That knowledge can help bridging the gap between the different attitudes toward sow husbandry of citizens and pig farmers. The objectives of this study were: 1) to describe a theoretical framework of basic values and attitudes related to sow husbandry, 2) to determine and compare basic values related to sow husbandry of (clusters) of citizens and pig farmers, 3) to test the hypothesis that basic values of citizens and pig farmers cannot predict one-on-one the attitudes toward sow husbandry of these groups, and 4) to find out how basic values can be useful in closing the gap between attitudes toward sow husbandry of (clusters of) citizens and pig farmers.

4.2 Theoretical framework

As a first step in this study, a theoretical framework was described (Figure 4.1). Related to this framework, different definitions will be used in the remainder of this article. These definitions are explained in Figure 4.2.

Attitudes

The lower part of the theoretical framework is related to attitudes toward sow husbandry. This part of the theoretical framework has been developed in earlier work (Bergstra et al., 2014a). This is also the work in which the four clusters of citizens described in the introduction were determined, meaning that the aspects presented in Table 4.1 are based on this part of the framework. With regard to sow husbandry, attitudes are directed toward three entities, i.e. animals, humans and the environment. Related to these entities there are aspects to which attitudes are related. These aspects were selected based on literature (see Bergstra et al., 2014a) and were related to issues of sow husbandry that have arisen in the Dutch media, from the year 2009 till 2011: piglet mortality, housing of pigs, scale increase of sow husbandry, interventions (castration, tail docking) in piglets, euthanasia of pigs, lifespan sow, piglet litter size, weaning age of piglets, motherless care of piglets, use of antibiotics in pigs and anesthetics used to sedate pigs. All issues and the related relevant

aspects are included in the framework. The use of anesthetics was covered by the issue 'castration' because the discussions about castration predominantly focused on whether or not to use anesthetics during the castration process.

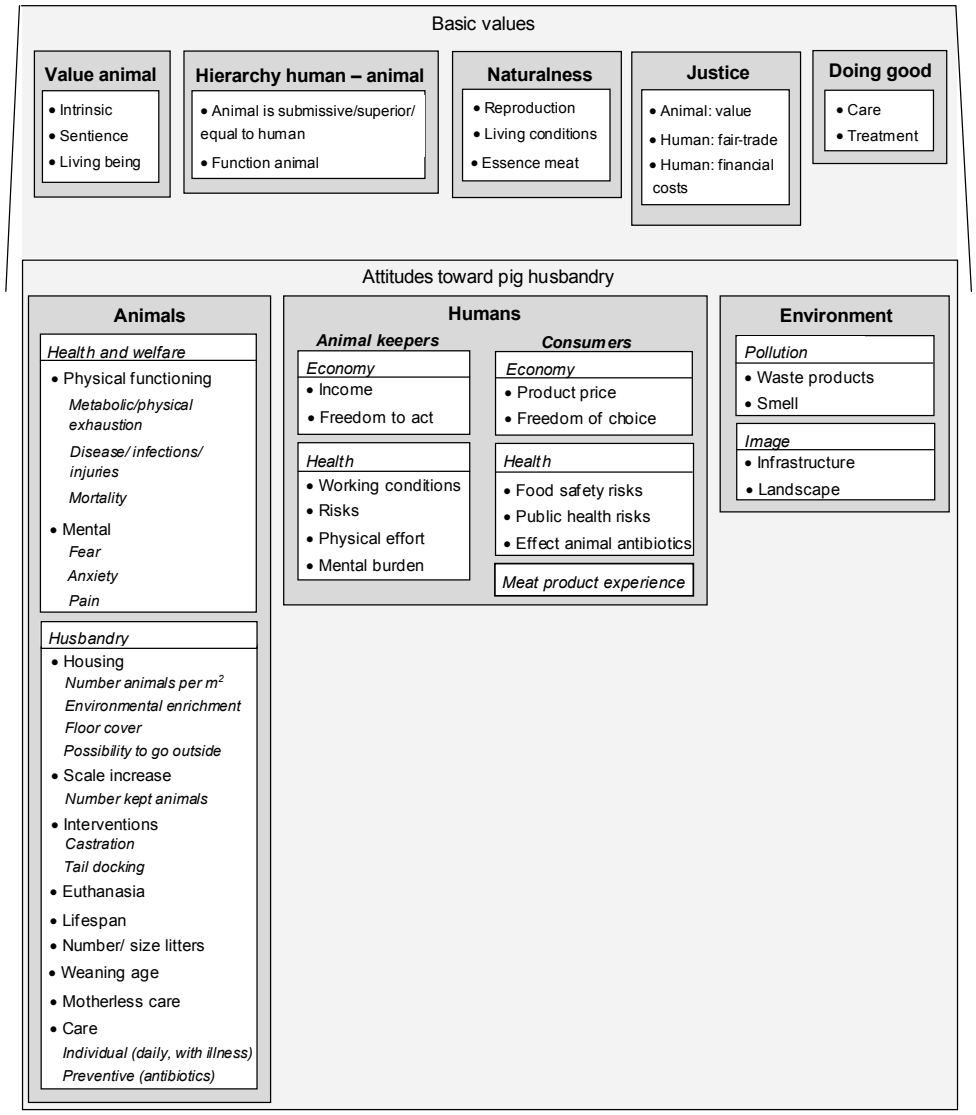

Figure 4.1 Framework for the assessment of basic values and attitudes toward pig husbandry. For basic values, factors toward which basic values are directed with regard to pig husbandry are presented. For attitudes, aspects per entity (i.e., animals, humans and the environment) that play a role in attitudes toward pig husbandry are presented.

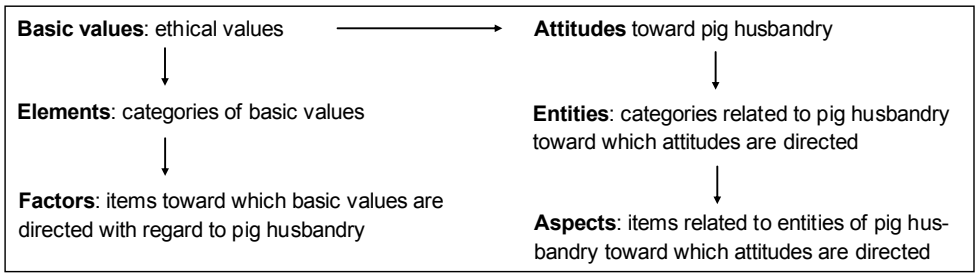

Figure 4.2 Definitions used related to the framework (Figure 4.1).

Basic values

The upper part of the theoretical framework is related to basic values with regard to sow husbandry. For the basic values the following elements were distinguished: value animal, hierarchy human-animal, naturalness, justice and doing good. These elements were considered relevant for sow husbandry based on literature (Cohen et al., 2009; Mepham, 2000; Michalopoulos et al., 2008). Both Mepham (2000) and Cohen et al. (2009) included the value of animals in their ethical model for animal production. Cohen et al. (2009) also included human-animal hierarchy, doing good to animals and the rights of animals. The rights of animals indicated the right to life of animals when it concerned the killing of healthy animals in an epidemic outbreak. As the focus of our framework was not on the killing of healthy animals, the right of animals was not included separately but was grouped under 'value animal'. Mepham (2000) included factors of the elements 'naturalness', i.e., behavioral freedom, and 'justice', and 'justice', i.e., fair-trade. Naturalness and economic fairness were included in the model of Michalopoulos et al. (2008), for analyses on public acceptability of production systems. It was stated that the same model, with some additions, could be used for animal production systems (Michalopoulos et al., 2008). In our framework, all elements of the basic values were divided into factors. The factors were mostly related to two kinds of basic values in public debates about sow husbandry: basic values related to animals, which are used to develop attitudes toward sow husbandry with respect to animal welfare, health and housing (see lower part of framework; Figure 4.1), and basic values related to humans which are used to develop attitudes toward sow husbandry with respect to animal keepers and consumers (see lower part of framework; Figure 4.1). Explanations of the factors are given in Table 4.2. The elements and factors of the basic values in the theoretical framework were validated by experts in the field of sow husbandry and animal welfare.

Table 4.2 Description of elements and factors of basic values that play a role in pig husbandry.

Element	*Factor*	*Description*
Value animal	Intrinsic	The intrinsic value is an animal's own value, independent of the value it has for humans, and is proven to be important in the evaluation of animals (Cohen 2010) and animal production systems (Mepham 2000).
	Sentience	Sentience is the animal's ability to feel pain and joy. Sentience is important in animal evaluation as animal welfare is mainly about feelings and animal experiences (Cohen 2010, Duncan 2006).
	Living being	When an animal is seen as a living being it has value. Animal value is proven to be important in animal evaluation (Cohen 2009).
Hierarchy human-animal	Submissive/ superior/ equal	The position someone has with respect to animals plays a role in animal evaluation (Cohen 2010).
	Function animal	What one finds to be the function of an animal, e.g. animals have to serve humans, plays a role in animal evaluation.
Naturalness	Reproduction	In an ethical debate about killing animals it was argumented that animals have the right to have a natural lifecycle, i.e. lifespan, reproduction, age of giving first birth, longevity (Asseldonk 2005). Reproduction is maximized in pig production so the level of natural reproduction plays an important role in pig husbandry evaluation.
	Living conditions	People want animals to have natural living conditions in which they can perform natural behaviour (Boogaard 2011). This naturalness plays a role in the assessment of animal welfare (Mepham 2000, Tuyttens 2010, Vanhonacker 2008, 2010).
	Essence meat	Meat is seen as a part of humans' diet (Aarts 2001). The importance of pig meat plays a role in the evaluation of pig husbandry.
Justice	Animal: value	The value of an animal will have an influence on how much justification an animal needs (Asseldonk 2005). In the evaluation of animal production systems, justice in relation to animal value is of importance (Mepham 2000).
	Human: fair-trade	Justice on fair-trade is important in the ethical debate about animal production systems (Driessen 2010, Mepham 2000) and food concerns (Michalopoulus 2008). In earlier research it is found that concerns exist about fair-trade (Driessen 2010).
	Human: financial costs	Justice on financial costs (affordable food) is important in the ethical debate (Mepham 2000). In earlier research it is found that concerns exist about human wealth, i.e. farmer income and regional economy (Driessen 2010).
Doing good	Care	People believe that humans have to care for all animals (Cohen 2010). The level of care that should be given is taken into consideration in the evaluation of pig husbandry.
	Treatment	People believe that humans have to protect all animals (Cohen 2010). A past of this protection is to treat animals when they are sick. How much treatment should be given is taken into consideration in the evaluation of pig husbandry.

4.3 Material and methods

Data collection

Based on the aforementioned theoretical framework a questionnaire was developed. The first part of the questionnaire included questions related to basic values. For all factors, except the factor 'animal (pig) is superior/equivalent/submissive to human', a theorem was given, such as 'pigs are sentient'. Per theorem respondents could indicate whether they strongly disagreed, disagreed, were neutral, agreed or strongly agreed. Besides including factors of the element 'naturalness' in this question, an extra question was added in which respondents could indicate what they found important with regard to naturalness. Respondents could indicate the level of importance (highly unimportant, unimportant, neutral, important, highly important) for different constituents of naturalness: possibility to go outside, social contact, freedom of movement, possibility to grub and mud bathe, good floor cover and ad libitum food and water. These levels of importance could indicate whether respondents interpret naturalness differently. In a separate question respondents could indicate whether they found animals superior, equivalent or submissive to humans.

The questionnaire also included questions about socio-demographic features, i.e., gender, age, level of education, religious (yes, no or a little), pets (yes or no) type of meat eaten, urban character of residence, region of residency in the Netherlands (north, middle or south) and size of childhood residence. The full questionnaire is available by contacting the first author of this paper.

The questionnaire was distributed via internet to citizens and pig farmers. A panel of 2,572 randomly selected citizens were invited, by a research institute with a directory of Dutch citizens representative for the Netherlands, to participate and could fill in the questionnaire two weeks of October 2011 (CentERdata, Tilburg, the Netherlands). One week after the invitation the panel received a reminder. Pig farmers were invited by an invitation letter. This letter was sent, after exclusion of pig farmers with less than 50 sows, to 1,000 randomly selected addresses from 2,399 pig farmers registered by TOPIGS (a global leader in pig breeding and artificial insemination, Helvoirt, the Netherlands). Two weeks after the first letter, the selected farmers received a reminder letter.

The response rates in the current study were as follows:

- Dutch Citizens: 1607 of 2572 (62.5%):
  - High-AC cluster: 645 of 1607 (40.1%)
  - Moderate-AC cluster: 623 of 1607 (38.8%)
  - Max-AC cluster: 225 of 1607 (14.0%)
  - No-Ac cluster: 114 of 1607 (7.1%)
- Dutch pig farmers: 181 of 1000 (18.1%).

The socio-demographic features of these groups are presented in Table 4.3. In general, respondents of citizens were representative for the Netherlands, except for age. Citizens respondents were on average older (81% > 40 years) than the Dutch population (59% > 40 years) (Centraal Bureau voor de Statistiek, 2011). Based on socio-demographic features (Table 4.3), the group of pig farmers was assumed to be representative for Dutch pig farmers because most pig farmers are male and lower educated.

Table 4.3 Percentage respondents per category of the socio-demographic features of clusters of citizens (Cl) and pig farmers (Pf).

Socio-demographic feature	Category	Cl1[a]	Cl2	Cl3	Cl4	Pf
Gender:	Male	51	60	48	64	95
	Female	49	40	52	36	5
Age:	15-24	2	5	3	4	1
	25-34	5	5	2	7	15
	35-44	13	17	9	15	32
	45-54	21	20	12	25	39
	55-64	27	23	36	25	13
	65-older	33	29	38	23	0
Education:	Primary school	4	5	6	4	0
	Secondary school (low)	26	25	40	22	4
	Secondary school (high)	13	13	8	15	6
	Vocational	16	16	16	15	59
	BSc	28	27	23	28	28
	MSc	13	15	6	15	2
Religious:	Yes	27	28	29	33	37
	No	52	52	42	55	32
	A little	22	20	28	12	31
Pets:	Yes	44	40	40	42	84
	No	56	60	60	58	16
Urbanity residence:	Extremely urban (>2500[b])	16	12	16	10	4
	Highly urban (1500-2500)	23	28	26	18	1
	Urban (1000-1500)	23	18	27	22	2
	Moderate urban (500-1000)	20	25	17	31	18
	Not urban (<500)	18	18	15	19	74
Childhood residence	Randstad[c]	30	23	27	11	1
	Big city	11	13	20	11	3
	Small city	18	17	16	13	10
	Big village	15	19	12	19	22
	Small village	26	28	26	46	64

[a] Cl1: high-AC cluster (n=645), Cl2: moderate-AC cluster (n=623), Cl3: max-AC cluster (n=225), Cl4: no-AC cluster (n=114), Pf: pig farmer (n=181).
[b] Number of inhabitants per square kilometer.
[c] Randstad is the most urban area in the Netherlands.

Data Analysis

First, a descriptive statistical analysis was carried out to study the basic values of (clusters of) citizens and pig farmers. Scores per factor of the basic values were presented by the percentage of respondents per cluster of citizens and pig farmers that disagreed (including strongly disagreed), were neutral or agreed (including strongly agreed) with the theorem. For the human-animal position, percentages of respondents per cluster of citizens and pig farmers were calculated for each position (superior, equivalent and submissive). To indicate what was found important with regard to the factor 'naturalness' of the basic values, the percentages of respondents that found the constituents naturalness unimportant (including highly unimportant), were neutral or found the constituents important (including highly important) were presented.

Second, ordered multinomial logistic regression was performed for the valuation of factors, which were non-normal distributed and categorical, of the basic values, except for the human-animal position. The impact of group membership, i.e., either citizens or pig farmers, β_k on levels of agreement for the factors of the basic values were estimated by maximizing the likelihood function $L(\beta_k) = \prod_{i=1}^{N} \prod_{j=1}^{J} [Prob(Y_i = j|x_i)]^{I(y_i=j)}$, where $Prob$ was the probability that respondent i of the total numbers of respondents N in group k scored j of the total number of choice options J, $I(y_i = j) = 1$ if respondent i choose score j and 0 otherwise. In this analysis group membership and individual socio-demographic features were included as explanatory variables. Socio-demographic features were included because it is proven that these features have an effect on basic values (Fraser, 1999). Of these variables, coefficient estimates and their significances were calculated. When there was a significant difference and the coefficient of β_k was negative (or positive), the probability that respondent i gave a lower (or higher) score than respondents in the other group became higher. More information about ordered multinomial logistic regression can be found in Greene and Hensher (2010).

Third, ordered multinomial logistic regression was performed for the valuation of all defined factors of the basic values and for levels of importance for constituents of naturalness, which were all non-normal and categorical. This time the clusters of citizens were included in group membership. The same equation as mentioned above was used with now k being a cluster of citizens or the group of pig farmers. In this analysis only cluster membership was included as explanatory variable.

Fourth, a Kendall's Tau rank correlation analysis was carried out to study the correlation between the valuation of the basic values and additional care (AC) levels assigned to aspects of sow husbandry (Table 4.1) and between the valuation of basic values and levels

of importance for constituents of naturalness. Kendall's τ was defined by $\mathcal{T} = (\mathrm{C} - \mathrm{D}) / \left(\frac{1}{2}\mathrm{n}(\mathrm{n}-1)\right)$, where C is the number of concordant pairs and D is the number of discordant pairs. To indicate the correlation, 0.6 was used as threshold because a correlation of > 0.6 corresponds roughly to more than 50% shared variance between correlated variables (Gross et al., 1992).
For statistical analyses IBM SPSS Statistics 19 (IBM Corporation, New York, United States) and EViews6 (IHS EViews, Irvine, United States) were used. In SPSS descriptive statistical analysis was performed, and in EViews all other analyses were carried out.

4.4 Results

Basic values

Citizens as one group agreed on the valuation of eight of the twelve factors of the basic values with pig farmers (> 50% agreed; Table 4.4). For the theorems 'function pig is meat for human' and 'meat essential for humans', more than 82% of the pig farmers agreed while less than 47% of citizens agreed. For the theorems 'reproduction should be natural' and 'living conditions should be natural', more than 65% of citizens agreed while less than 43% of pig farmers agreed. When different clusters of citizens are compared with pig farmers in the valuation of the basic values, differences are shown in seven out of twelve factors of the basic values (Table 4.5). For the theorems 'pigs are sentient', 'treat pigs to their own value', 'fair trade is important in meat production', 'include financial costs in meat production' and 'pigs should be individually treated' more than 61% of all groups agreed. For the other theorems pig farmers mostly agreed with citizens in the no-AC cluster (7.1% of citizens), followed by citizens in the moderate-AC cluster (38.8% of citizens). For the theorems 'pigs have intrinsic value', 'pigs are living beings', 'reproduction should be natural' and 'living conditions should be natural', citizens in the high-AC cluster and the max-AC cluster in general agreed more often than pig farmers and citizens in the moderate-AC cluster and the no-AC cluster. This was the other way around for the theorem 'meat is essential for humans', i.e., citizens in the high-AC cluster and the max-AC cluster agreed less often. To the theorem 'function pig is meat for humans' more than 70% of the no-AC cluster and pig farmers agreed against less than 44% of the other clusters. Citizens in the high-AC cluster and the max-AC cluster mostly agreed with pig farmers (>62% agreed) on the theorem 'pigs should be individually cared for'. On this theorem less than 36% of citizens in the moderate-AC cluster and the no-AC cluster agreed.

Table 4.4 Percentage of respondents per level of agreement (D: disagree (including strongly disagree), N: neutral and A: agree (including strongly agree)) per theorem of the basic values related to pig husbandry of citizens (n=1607) and pig farmers (n=181), and significant differences (P) per theorem between citizens and pig farmers.

		Citizens			Pig farmers			
Element	Theorem	D	N	A	D	N	A	P
Value	*Pigs have intrinsic value*	6.3	29.6	64.1	14.4	35.4	49.6	0.06
	Pigs are sentient	2.7	17.3	80.0	6.1	16.0	77.3	0.07
	Pigs are living beings	7.2	33.6	59.2	11.7	35.9	51.8	0.59
Hierarchy	*Function pig is meat for humans*	22.8	37.1	40.1	1.7	15.4	82.3	<0.01
Naturalness	*Reproduction should be natural*	4.4	30.1	65.5	22.7	35.4	42.0	<0.01
	Living conditions should be natural	3.4	23.8	72.8	38.7	39.2	21.0	<0.01
	Meat essential for humans	23.3	29.9	46.7	1.1	7.2	91.7	<0.01
Justice	*Treat pigs to their own value*	1.6	16.8	81.6	2.2	16.6	81.2	0.61
	Fair-trade is important in meat	2.3	16.6	81.1	4.4	14.4	80.5	0.60
	Include costs in meat production	3.0	19.8	77.2	0.0	1.7	97.7	<0.01
Doing good	*Pigs should be individually cared*	15.4	33.6	51.0	9.9	11.6	78.5	<0.01
	Pigs should be individually treated	2.7	13.6	83.6	1.7	6.6	91.1	<0.01

Table 4.5 Percentage of respondents per level of agreement (D: disagree (including strongly disagree), N: neutral and A: agree (including strongly agree)) per theorem of the basic values related to pig husbandry of clusters of citizens (Cl) and pig farmers (Pf). Per theorem, the differences between clusters of citizens and pig farmers were significant unless stated otherwise.

Element	Theorem	Group	D	N	A	Not Sign.[b]
Value animal	*Pigs have intrinsic value*	Cl1[a]	2.6	18.6	78.8	a
		Cl2	7.9	44.3	47.8	
		Cl3	1.8	15.6	82.7	
		Cl4	26.3	41.2	32.5	
		Pf	14.4	35.6	50.0	a
	Pigs are sentient	Cl1	1.4	10.2	88.4	
		Cl2	3.4	26.8	69.8	a
		Cl3	0.9	9.8	89.3	
		Cl4	9.6	21.1	69.3	a
		Pf	6.1	16.1	77.8	a
	Pigs are living beings	Cl1	4.0	25.1	70.9	
		Cl2	10.1	45.9	44.0	a
		Cl3	1.3	16.9	81.8	
		Cl4	21.1	48.2	30.7	
		Pf	11.7	36.1	52.2	a
Hierarchy	*Function pig is meat for humans*	Cl1	31.5	36.6	31.9	a
		Cl2	14.3	41.9	43.8	
		Cl3	31.1	30.7	38.2	a
		Cl4	4.4	25.4	70.2	b
		Pf	1.7	15.6	82.8	b

Naturalness	*Reproduction should be natural*	Cl1	3.1	19.7	77.2	
		Cl2	3.9	44.1	52.0	
		Cl3	2.2	13.8	84.0	
		Cl4	20.2	45.6	34.2	a
		Pf	22.7	35.4	42.0	a
	Living conditions should be natural	Cl1	1.1	11.0	87.9	
		Cl2	3.9	40.8	55.4	
		Cl3	0.0	6.2	93.8	
		Cl4	20.2	38.6	41.2	
		Pf	39.1	39.7	21.2	
	Meat essential for humans	Cl1	32.2	29.3	38.4	a
		Cl2	14.3	34.7	51.0	
		Cl3	28.0	26.2	45.8	a
		Cl4	13.2	14.9	71.9	
		Pf	1.1	7.2	91.7	
Justice	*Treat pigs to their own value*	Cl1	0.5	7.4	92.1	
		Cl2	1.9	28.7	69.3	
		Cl3	0.0	3.1	96.9	
		Cl4	9.6	31.6	58.8	
		Pf	2.2	16.6	81.2	
	Fair-trade is important in meat production	Cl1	0.8	9.5	89.8	
		Cl2	2.7	26.8	70.5	a
		Cl3	0.4	4.0	95.6	
		Cl4	12.3	26.3	61.4	
		Pf	4.4	14.4	81.1	a
	Include financial costs in meat production	Cl1	3.3	15.5	81.2	a
		Cl2	2.9	28.3	68.9	
		Cl3	2.2	12.0	85.8	
		Cl4	3.5	13.2	83.3	a
		Pf	0.0	1.7	98.3	
Doing good	*Pigs should be individually cared for*	Cl1	10.1	27.8	62.2	
		Cl2	21.5	46.2	32.3	a
		Cl3	2.7	19.6	77.8	b
		Cl4	36.8	28.1	35.1	a
		Pf	9.9	11.6	78.5	b
	Pigs should be individually treated	Cl1	1.2	5.9	92.9	a
		Cl2	3.7	23.3	73.0	c
		Cl3	0.9	4.4	94.7	b
		Cl4	9.6	22.8	67.5	c
		Pf	1.7	6.7	91.7	a,b

[a] Cl1: high-AC cluster (n=645), Cl2: moderate-AC cluster (n=623), Cl3: Max-AC cluster (n=225), Cl4: no-AC cluster (n=114), Pf: pig farmer (n=181).
[b] Per theorem, the groups with the same letter (a, b or c) did not differ significantly in percentage of respondents per choice option (strongly disagree, disagree, neutral, agree and strongly agree).

Table 4.6 Percentage respondents per hierarchical position with regard to pigs of clusters of citizens (Cl) and pig farmers (Pf). The differences between clusters of citizens and pig farmers were significant unless stated otherwise.

Group	Pig superior to human	Pig equal to human	Pig submissive to human	Not sign.
Cl1	0.2	20	79.8	a
Cl2	0.5	9.5	90	
Cl3	0	20.4	79.6	a
Cl4	0	2.6	97.4	b
Pf	0.5	1.7	97.8	b

[a] Cl1: high-AC cluster (n=645), Cl2: moderate-AC cluster (n=623), Cl3: Max-AC cluster (n=225), Cl4: no-AC cluster (n=114), Pf: pig farmer (n=181).
[b] The groups with the same letter (a, b or c) did not differ significantly in percentage of respondents per choice option (superior, equal or submissive).

For the hierarchical position human-pig, more than 79% of all respondents agreed that pigs are submissive to humans (Table 4.6). Respondents in the no-AC cluster agreed most with pig farmers (>97% agreed on pigs being submissive to humans) and respondents in the high-AC agreed most with respondents in the max-AC cluster (around 80% agreed on pigs being submissive to humans and around 20% agreed on pigs being equal to humans).
With regard to naturalness, more than half of all citizens and pig farmers found the freedom of movement and good floor cover important (Table 4.7). Ad libitum food and water was found important by more than 66% of citizens in the high-AC cluster and the max-AC cluster against less than 50% of the other clusters and pig farmers finding this important. Less than 45% of the pig farmers found social contact important, while more than 53% of all citizens did find this important. For the possibility to go outside and the possibility to grub and mud bathe, only 5% of the pig farmers indicated to find this important. More than 66% of citizens in the clusters, except the no-AC cluster, did find this important. Between 43% and 50% of citizens in the no-AC cluster found this important.

Relation basic values and attitudes

Results of the Kendall's Tau rank correlation analysis are shown in Table 4.8. Even though almost all correlations were significant ($P<0.05$), correlations had to be 0.6 or higher in order to be meaningful. The only correlations that were found to be useful were those between the valuation of the factor 'living conditions pig must meet natural demands' of the basic values and the levels of importance for the constituents 'possibility to go outside' (correlation of 0.604) and 'possibility to grub and mud bathe' (correlation of 0.603) of naturalness.

Table 4.7 Percentage of respondents per level of importance (U: unimportant (including highly unimportant), N: neutral, I: important (including highly important)) per constituent of naturalness of clusters of citizens (Cl) and pig farmers (Pf). Per constituent, the differences between clusters of citizens and pig farmers were significant unless stated otherwise.

Constituents of naturalness	Group	U	N	I	Not sign.[b]
Possibility to go outside	Cl1[a]	1.6	7.3	91.2	
	Cl2	2.6	29.1	68.4	
	Cl3	0.0	2.2	97.8	
	Cl4	26.3	29.8	43.9	
	Pf	74.4	20.6	5.0	
Social contact	Cl1	1.7	11.8	86.5	
	Cl2	3.7	31.5	64.8	
	Cl3	0.0	5.3	94.7	
	Cl4	20.2	26.3	53.5	a
	Pf	19.3	36.5	44.2	a
Freedom of movement	Cl1	0.3	2.0	97.7	
	Cl2	0.2	15.4	84.4	
	Cl3	0.0	1.3	98.7	
	Cl4	5.3	21.1	73.7	a
	Pf	3.9	17.1	79.0	a
Possibility to grub and mud bathe	Cl1	1.6	8.2	90.2	
	Cl2	2.6	30.5	66.9	
	Cl3	0.0	2.7	97.3	
	Cl4	21.9	28.9	49.1	
	Pf	76.1	18.9	5.0	
Good floor cover	Cl1	0.8	5.4	93.8	
	Cl2	1.4	22.6	75.9	a
	Cl3	0.0	2.7	97.3	
	Cl4	3.5	21.9	74.6	a
	Pf	17.2	31.1	51.7	
Ad lib food and water	Cl1	2.2	31.0	66.8	
	Cl2	3.4	49.3	47.4	a
	Cl3	1.3	17.3	81.3	
	Cl4	10.5	40.4	49.1	a
	Pf	32.2	35.0	32.8	

[a] Cl1: high-AC cluster (n=645), Cl2: moderate-AC cluster (n=623), Cl3: Max-AC cluster (n=225), Cl4: no-AC cluster (n=114), Pf: pig farmer (n=181).

[b] Per constituent, the groups with the same letter (a, b or c) did not differ significantly in percentage of respondents per choice option (highly unimportant, unimportant, neutral, important and highly important).

Table 4.8 Correlation matrix of levels of importance for constituents of naturalness and levels of additional care for aspects of pig husbandry given by citizens and pig farmers against levels of agreement for theorems of basic values. All correlations were significant. A threshold of 0.6 was used for a useful correlation (bold and underlined correlations were useful).

		Basic values*											
		1	2	3	4	5	6	7	8	9	10	11	12
Naturalnes	Possibility to go outside	.363	.295	.323	-.356	.440	**.604**	-.302	.384	.314	-.017	.160	.225
	Social contact without bars	.400	.373	.376	-.262	.363	.506	-.215	.435	.368	.108	.228	.279
	Freedom of movement	.395	.391	.390	-.253	.376	.511	-.188	.494	.430	.165	.249	.370
	Possibility grub and mud bathing	.357	.276	.328	-.342	.405	**.603**	-.304	.387	.299	-.014	.144	.199
	Good floor cover	.347	.336	.341	-.206	.351	.472	-.172	.442	.394	.149	.200	.313
	Ad lib food and water	.214	.166	.216	-.122	.245	.348	-.108	.267	.224	.006	.114	.158
Attitudes animals	Quality/quantity feed	.199	.124	.205	-.129	.201	.293	-.126	.215	.175	.006	.156	.149
	Rate sickness/infection/injury	.245	.194	.225	-.167	.259	.349	-.134	.279	.258	.037	.165	.219
	Mortality	.269	.193	.254	-.201	.257	.357	-.157	.287	.236	.028	.181	.209
	Fear/anxiety	.342	.285	.308	-.235	.338	.451	-.219	.376	.304	.070	.203	.262
	Pain	.350	.264	.311	-.242	.319	.449	-.206	.364	.289	.050	.191	.241
	Number of kept animals	.300	.231	.270	-.261	.380	.463	-.255	.323	.273	.011	.154	.208
	Environmental enrichment	.308	.268	.306	-.253	.304	.419	-.229	.340	.253	.037	.186	.202
	Number of animals per m2	.305	.260	.290	-.267	.367	.483	-.260	.355	.299	.020	.155	.224
	Floor cover	.304	.256	.285	-.242	.336	.454	-.238	.337	.300	.023	.176	.231
	Possibility to go outside	.307	.237	.262	-.300	.403	.520	-.290	.331	.262	-.030	.116	.179
	Tail docking	.297	.210	.281	-.252	.280	.394	-.232	.286	.252	-.004	.181	.192
	Castration	.299	.199	.272	-.219	.242	.360	-.197	.275	.249	.034	.218	.192
	Time euthanasia	.276	.203	.260	-.162	.211	.314	-.123	.286	.240	.045	.213	.218
	Lifespan sow	.303	.214	.299	-.248	.291	.405	-.205	.331	.258	-.001	.200	.221
	Number of litters per sow	.269	.200	.260	-.257	.309	.416	-.240	.289	.247	-.031	.157	.193
	Litter size	.247	.160	.234	-.232	.276	.378	-.210	.275	.233	-.022	.166	.176
	Weaning age	.300	.224	.288	-.259	.300	.434	-.236	.316	.267	.000	.199	.216
	Motherless care	.291	.229	.283	-.236	.288	.385	-.210	.322	.275	.023	.181	.216
	Care for individual animal	.354	.255	.333	-.264	.321	.447	-.239	.380	.304	.034	.264	.272
	Use of antibiotics (animal)	.256	.255	.214	-.141	.243	.319	-.145	.288	.307	.123	.121	.232

Attitudes animal keepers	Enough income	.064	.068	.077	.114	.014	-	.155	.092	.125	.306	.149	.147
	Freedom to act	.012	-	.030	.074	.037	.007	.081	.058	.070	.081	.078	.055
	Working conditions	.145	.083	.142	-.030	.144	.167	-.006	.142	.162	.104	.116	.115
	Health risks	.186	.153	.192	-.079	.185	.235	-.086	.194	.235	.130	.105	.141
	Physical burden	.140	.085	.172	-.036	.152	.181	-.009	.137	.177	.119	.139	.119
	Mental burden	.122	.076	.152	.025	.093	.105	.041	.126	.178	.172	.147	.119
Attitudes consumers	Price product	.090	.038	.091	.069	.046	.015	.088	.093	.129	.155	.143	.118
	Freedom of choice	.107	.065	.120	-.017	.128	.145	.013	.126	.158	.061	.108	.095
	Food safety risks	.188	.192	.179	-.133	.245	.296	-.125	.246	.285	.081	.097	.137
	Public health risks	.199	.197	.184	-.135	.243	.307	-.130	.250	.286	.092	.086	.144
	Use of antibiotics (human)	.235	.236	.207	-.128	.252	.305	-.151	.277	.317	.131	.110	.196
	Experience meat products	.148	.090	.152	-.002	.112	.122	.009	.178	.198	.121	.178	.152
Attitudes environm.	Environmental waste	.261	.219	.243	-.220	.308	.396	-.222	.274	.289	.033	.136	.166
	Smell	.239	.177	.244	-.190	.276	.366	-.206	.261	.260	.022	.163	.143
	Change in infrastructure	.170	.093	.178	-.123	.202	.269	-.147	.197	.202	.003	.123	.116
	Image landscape	.195	.122	.205	-.166	.234	.314	-.173	.219	.247	.005	.162	.130

***** Basic values: 1: pigs have intrinsic value, 2: pigs are sentient, 3: pigs are living beings, 4: function pig is meat for humans, 5: reproduction should be natural, 6: living conditions should be natural,7: meat essential for humans, 8: pigs should be treated to their own value, 9: fair-trade is important in meat production, 10: financial costs should be included in meat production, 11: pigs should be individually cared for, 12: pigs should be individually treated.

4.5 Discussion

The present study focused on basic values related to sow husbandry of (clusters of) citizens and pig farmers and looked at the relation between basic values and attitudes toward sow husbandry. In a previous study (Bergstra et al., 2014b), the attitudes of citizens and pig farmers were determined to be different and it was shown that these attitudes also differ between four clusters of citizens. To determine the basic values of these groups, a questionnaire was send out to people of these groups. The number of respondents in the group of citizens was higher than the number of respondents in the group of pig farmers. This was the result of using different approaches. Citizens were approached through a research institute with a directory of Dutch citizens representative for the Netherlands who voluntarily participate in surveys, while we approached pig farmers ourselves unannounced. Respondents of pig farmers and citizens differed in socio-demographic features. Pig farmers were assumed to be representative for their group, but citizens were not fully representative of the Dutch population because of relatively more older respondents. It is proven that socio-demographic features have an effect on basic values and attitudes toward animal husbandry (Boogaard et al., 2006; Cohen et al., 2012; Frederiksen et al., 2010; Herzog, 2007; Kendall et al., 2006; Knight et al., 2004; María, 2006; Prickett et al., 2010; Tuyttens et al., 2010). Studies showed that older people have more negative attitude toward animal husbandry with respect to animal welfare than younger people (Bergstra et al., 2014a; Frederiksen et al., 2010; Knight et al., 2004). As the group of citizens was not fully representative for the Netherlands, a correction was made for socio-demographic features in the analysis to compare basic values of citizens as a single group and pig farmers. This way it was assured that differences in basic values between these groups were not influenced by socio-demographic features. In the analysis of basic values of different clusters of citizens, based on attitudes toward sow husbandry (Bergstra et al., 2014a), and pig farmers this correction was no longer used, because these groups are characterized by their socio-demographic features. This means that respondents in all these clusters were representative for that group.

Basic values, i.e. the core values used for moral reasoning, underlie attitudes (Rokeach, 1968-1969). This could indicate that differences in attitudes toward sow husbandry between citizens and pig farmers can be predicted by their basic values. However, based on the conclusion of Cohen (2010a, 2012) that moral values can only predict the judgment of culling healthy animals in the course of a disease epidemic to a certain extent, we hypothesized that basic values of citizens and pig farmers cannot predict one-on-one the

attitudes toward sow husbandry of these groups. To test this hypothesis, we determined and compared the valuation of basic values toward sow husbandry given by citizens and pig farmers and tested whether these valuations can be related to additional care (AC) levels that these groups assigned to aspects of sow husbandry (Table 4.1). This was done by means of a correlation test. One-on-one correlations were found between the valuation of basic values and additional care (AC) levels assigned to aspects of sow husbandry, but these correlations were too low to be meaningful. This means that basic values indeed cannot one-on-one predict attitudes toward sow husbandry, which can be explained by citizens and pig farmers sharing valuations of most of the basic values (eight out of twelve) but that they differ in attitudes toward sow husbandry with respect to almost all defined aspects. That basic values related to sow husbandry are shared by citizens and pig farmers can partly be explained by that the development of basic values is influenced by culture, social background and law (Fraser, 1999), which are comparable for both groups. However, sharing the valuation of basic values does not result in sharing attitudes toward a specific animal practice (Cohen, 2010a; Cohen et al., 2010 b). The difference in attitudes toward sow husbandry between citizens and pig farmers may be explained by a difference in weighing basic values. These values are being weighed against other personal values and interest with regard to a context (Cohen et al., 2009), in this case sow husbandry. In the context of sow husbandry, pig farmers have different interests than citizens. Pig farmers have an interest in economics (De Greef and Casabianca, 2009) and are, therefore, interested in physical animal welfare and production (Bock et al., 2007b; Bracke et al., 2005; Van Huik and Bock, 2007). Citizens are interested in both physical and mental animal welfare (Te Velde et al., 2002) and find naturalness important (Lassen et al., 2006; Verbeke, 2009). The higher importance of naturalness for citizens than for pig farmers was shown especially in the constituents ‘possibility to go outside’ and ‘possibility to grub and mud bathe’. The level of importance assigned to these constituents were correlated to valuation of the factor ‘living conditions should be natural’ of the basic values. This means that these constituents of naturalness play an important role for citizens in their basic values related to sow husbandry, while for pig farmers they do not. As a result, citizens weigh their basic values differently and give a different interpretation to the importance of basic values than pig farmers. For example, the possibility to go outside and the possibility to grub and mud bathe can be seen as important for pigs to have freedom of movement and for the possibility to perform natural behavior. The freedom of movement and the possibility to perform natural behavior were, in the present study and in previous studies (Boogaard et al., 2011 b; Te Velde et al., 2002), found to be important for both citizens and pig farmers. Probably, citizens interpret the freedom of movement and natural behavior different than

pig farmers and give a higher weight to the basic value 'living conditions should be natural'. In interpreting and weighting basic values, for pig farmers the context plays an important role. In the context of sow husbandry, pig farmers will think of the possibilities within their farming system with regard to naturalness. In this system it is difficult to give pigs the possibility to go outside. Therefore, pig farmers search for other solutions for the freedom of movement and the performance of natural behavior of pigs, such as more surface per animal and the possibility to see and hear conspecifics.

Although basic values cannot predict one-on-one the attitudes toward sow husbandry, it is useful to know if there are more or less differences in basic values between the four clusters of citizens with different attitudes toward sow husbandry and pig farmers in order to bridge the gap between these different attitudes. Results of the present study show that the valuations of most of the basic values related to sow husbandry are shared by pig farmers and citizens in the no-AC cluster followed by the moderate-AC cluster. However, citizens in the high-AC cluster and the max-AC cluster did not share the valuation of seven of the twelve factors of basic values with pig farmers. The difference between these clusters and pig farmers may be explained by the value animals have for humans. Cohen (2010) showed that farmers indicated that animals have a functional value, which is mainly a function for humans. In our study this is reflected in the high percentage (82,8% and 91,7% respectively) of pig farmers that agreed on the theorems 'function pig is meat for humans' and 'meat is essential for humans'. For both these theorems, citizens in the high-AC cluster and the max-AC cluster agreed much less (< 38.3% and <45,9% respectively). The different scores of these citizens and pig farmers may be explained by a different form of relationship with animals. The relationship pig farmers have with animals is that of the 'enlighted ruler'. The 'enlighted ruler' takes the leading role in the relation with animals to improve performance (De Cock Buning, 2005). Citizens tend to have more and more a partner relationship with animals (Rollin, 2004). The partner looks at the animals as different from humans but not as an unequal party in the relationship (De Cock Buning, 2005). Due to this relationship, pigs are seen as different but they should be treated equally to humans and they should not be seen as a commodity for humans. This relation is reflected in the relatively high percentage of citizens in the high-AC cluster and the max-AC cluster that indicated to find pigs equal to humans.

In our view the gap between the basic values of citizens in both the max-AC cluster and the high AC-cluster and pig farmers is too big to easily bridge the gap in their attitudes toward sow husbandry. For pig farmers to bridge this gap, the moderate-AC cluster can be helpful.

The moderate-AC cluster is a relatively large group of citizens (39%) that share the valuation of relatively many basic values, such as pigs have intrinsic value and meat is essential for humans, with pig farmers compared to citizens in the high-AC cluster and the max-AC cluster. This makes it more easy for pig farmers to understand the moral reasoning of citizens in the moderate-AC cluster than of citizens in the high-AC cluster and the max-AC cluster. Citizens in the moderate-AC cluster also differ from pig farmers in the valuation of some of the basic values, such as 'living conditions should be natural', while they share valuation of these basic values with citizens in the high-AC cluster and the max-AC cluster. This means that citizens in the moderate-AC interpret naturalness in a similar way as citizens in the high-AC cluster and the max-AC cluster. Pig farmers can use their understanding of the moral reasoning of citizens in the moderate-AC cluster to learn to understand their interpretation of naturalness. When they understand their interpretation of naturalness they can more easily understand the moral reasoning of citizens in the high-AC cluster and the max-AC cluster. Pig farmers can use this understanding in the development of new systems and measures to improve animal welfare and in their communication to society in order to bridge the gap in attitudes toward sow husbandry between them and citizens.

4.6 Conclusions

To study basic values we developed a theoretical framework of basic values and attitudes related to sow husbandry. A questionnaire that was based on this framework determined that the basic values toward sow husbandry of citizens as one group and pig farmers agree on the valuation of most of the basic values. The valuation of these basic values were not one-on-one related to additional care (AC) levels assigned to aspect of sow husbandry. This means that the hypothesis 'basic values of citizens and pig farmers cannot one-on-one predict the attitudes toward sow husbandry of these groups' can be confirmed. A difference in these attitudes between citizens and pig farmers may be explained by how they weigh and interpret the basic value 'living conditions should be natural' in which the importance of the possibility for pigs to go outside and the possibility for pigs to grub and mud bathe play a role. Citizens find these possibilities for pigs important while pig farmers do not. As a consequence, citizens give a higher weight to the basic value living conditions should be natural' than pig farmers.

When comparing four clusters of citizens with different attitudes toward sow husbandry, there were two clusters, i.e., the high-AC cluster and the max-AC cluster, that often did not

agree with pig farmers in their valuation of basic values related to sow husbandry. The other two clusters, i.e., the moderate-AC cluster and the no-AC cluster, shared most of the valuation of basic values related to sow husbandry with pig farmers. However, the moderate-AC cluster valuated the basic values 'living conditions should be natural' much higher than the pig farmers, while they shared this valuation with the high-AC cluster and the max-AC cluster. Because the moderate-AC cluster shares the valuation with the latter two clusters and with pig farmers, this cluster can be useful for pig farmers. When pig farmers learn to understand how the interpretation and weighing of the moral value 'living conditions should be natural' contributes to the moral reasoning of the moderate-AC cluster, this can be used in the development of new systems and measures for sow husbandry to improve animal welfare and in their communication to society. This means that even without the possibility to use basic values to predict one-on-one the attitudes toward sow husbandry, basic values can be useful to bridge the gap in attitudes toward sow husbandry between citizens and pig farmers.

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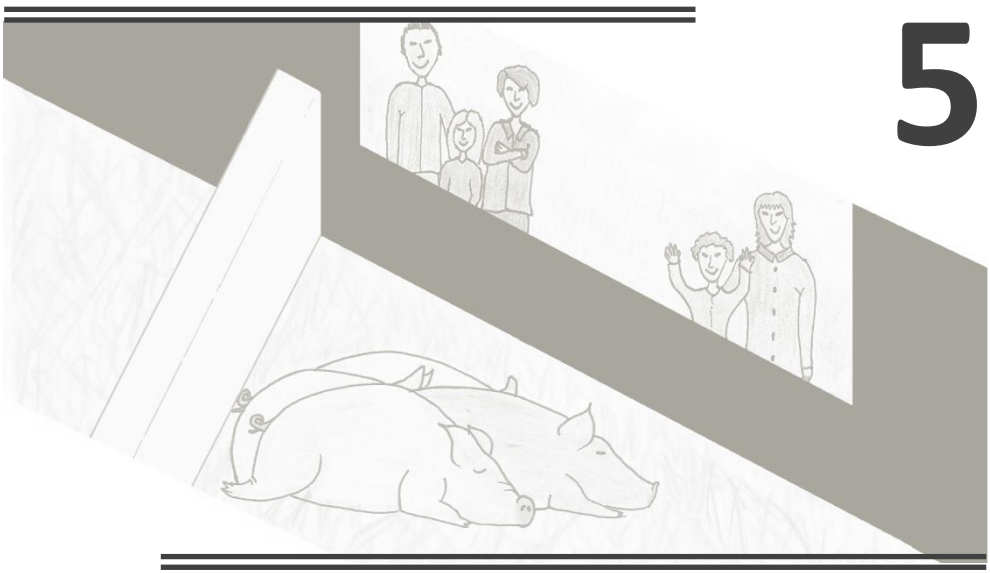

5

The effects of sow husbandry measures on animal welfare and farm income

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Under review

Abstract

Citizens in western societies are concerned about pig welfare. In order to meet these concerns, the pig sector has to implement measures to improve animal welfare. For measures to get accepted by both pig farmers and citizens it is important that measures meet both animal welfare and economic requirements. The objective of this study was to determine and compare the effects of different measures for sow husbandry on animal welfare and economic costs at farm level. Three issues of sow husbandry were selected; piglet mortality, tail biting and indoor housing. For each issue, four measures were described that can be implemented in an existing sow farm and have a positive effect on animal welfare. The effects of these measures in a reference farm were estimated with a simulation model, i.e., the animal-welfare-economics (WelEC) model, consisting of an economic and an animal welfare module. The outputs of the modules provided an estimation of the net farm income and an animal welfare score. With a cost-effectiveness ratio, i.e., the change in net farm income relative to a default situation divided by the change in animal welfare score relative to the default situation, the different measures for animal welfare improvement were compared. The measures to reduce piglet mortality were the only measures with a positive effect on net farm income. These measures showed the highest cost-effectiveness ratios compared to the other measures. However, the piglet mortality measures had a relatively low effect on animal welfare. The highest effects on animal welfare compared to the other measures were given by the measure in which gestating sows get the possibility to free range outside and the measure in which the groups of gestating sows are increased and in which the sows receive straw and windows in the outside wall. These measures had a negative effect on total net farm income but were the most cost-effective compared to the other defined measures with a negative effect on net farm income. Our results show that a positive effect of measures to improve animal welfare in sow husbandry on animal welfare do not necessarily have a negative effect on net farm income. Therefore, before deciding on the implementation of new measures to improve animal welfare on sow farms, it is important to evaluate both the effects of these measures on animal welfare and net farm income. This way, the interests of both citizens and farmers are met.

Key words

Animal welfare, economics, measures, sow husbandry

5.1 Introduction

Western societies are concerned about the welfare of animals in animal husbandry systems, including pig husbandry (Bergstra et al., 2014; Ingenbleek et al., 2004; Meuwissen and van der Lans, 2005). Citizens' concerns about animal welfare on pig farms are reflected in negative attitudes toward, for example, pig housing, tail docking, castration and the effect of the use of antibiotics on animals (Barnett et al., 2001b; Bergstra et al., 2014; Marchant-Forde, 2009; Meuwissen and van der Lans, 2005). To decrease negative attitudes of citizens, the pig sector has implemented several measures to improve animal welfare. However, these measures seem to have no positive effect on citizens' negative attitudes toward pig husbandry. That the implemented measures were unsuccessful regarding attitudes can be seen from the fact that citizens' attitudes toward pig husbandry stay negative through the years (Aarts et al., 2001; Bergstra et al., 2013; De Greef et al., 2006; Meuwissen and van der Lans, 2005). That measures do not have the desired effect may be caused by choices made in measure design. Measures are designed to be economically viable for pig farmers (De Greef and Casabianca, 2009) because pig farmers give high importance to economics as they depend on it in their business (Bracke et al., 2005; Te Velde et al., 2002). When citizens consider animal related measures for pig husbandry they mainly focus on animal welfare (Bergstra et al., 2013). This means that there is a discrepancy between pig farmers and citizens in what they believe is most important in measures for pig husbandry. For these measures to get accepted by both pig farmers and citizens it is, therefore, important that measures meet both animal welfare and economic requirements. Therefore, it is necessary to know what the effects of measures for pig husbandry are on animal welfare and economics. A few studies aimed at the economic consequences of animal welfare improvement (Bornett et al., 2003; Bruijnis et al., 2013; Cain and Guy, 2006; Gocsik et al., 2013; Seddon et al., 2013; Stott et al., 2012; Vosough Ahmadi et al., 2011). Bornett et al. (2003), Cain et al. (2006) and Vosough Ahmadi et al. (2011) compared different pig housing or farrowing systems in their effects on animal welfare and economics and Stott et al. (2012) did this for sheep production systems. Seddon et al. (2013) estimated the costs of different high welfare farrowing systems compared to a standard farrowing crate. Gocsik et al. (2013) analyzed the effects of animal welfare measures for broiler farms on economics. Bruijnis et al. (2013) compared economic and animal welfare effects of different measures for dairy cow foot improvement. None of the aforementioned studies looked at the improvement of animal welfare as well as the change in farm income of different measures for animal welfare improvement on an existing sow farm. Therefore, the objective of this study was to determine and compare the

effects of different measures for sow husbandry on animal welfare and economic costs at farm level. To meet the objective, a farm level simulation model was developed.

5.2 Material and methods

In order to calculate the effects of different measures for pig husbandry on animal welfare and economics, several steps were taken. Firstly, animal welfare issues of sow husbandry were selected to focus on. Secondly, a reference sow farm was defined. Thirdly, different measures to improve animal welfare for each animal welfare issue were described. Finally, a simulation model was developed to calculate economic and animal welfare effects of the different measures. The results of the model were used to compare the different measures.

Animal welfare issues

In a previous study at least 60% of Dutch respondents mentioned to find tail docking, interventions without sedation and indoor animal housing to be unacceptable (Bergstra et al., 2013). These results were the basis for two of the selected animal welfare issues: tail biting and indoor housing. The third issue, i.e., piglet mortality, was selected based on the large amount of media attention it received (Stichting Varkens in Nood, 2011; Wakker dier, 2011). The three issues were the focus in the remainder of the study.

Table 5.1 Characteristics of the reference sow farm

Characteristics	Value
Number of sows	400
Number of litters per sow per year	2.36
Live born piglets per litter	13.8
Piglet mortality	13%
Sows replaced	43%
Weaning age	26 days
Piglet age when sold	10 weeks
Number sows per group	20
Number weaned piglets per group	40
Number gestation crates	320
Number farrowing pens	120
Number weaned piglet pens	50
Surface sow pen per group	42 m2
Surface gestation crate	1.3 m2
Surface weaned piglet pen	16 m2

Sources: Agrovision (2012), KWIN-Veehouderij (2013/2014) and an in-depth interview with a farmer owning a sow farm comparable to the reference sow farm.

Reference sow farm

We defined a reference sow farm representative for the Netherlands. The characteristics of this sow farm were based on available statistics (Agrovision b.v., 2012), an in-depth interview with a conventional sow farmer and expert knowledge (Table 5.1). The reference sow farm deals with the aforementioned issues as follows:

- Piglet mortality:

From five days before farrowing, sows are confined in farrowing pens with one chain as enrichment material. The farrowing pen has a slatted metal floor with an area of 0.6 m^2 solid floor for the piglet nest (Figure 5.1a). Sows stay confined until piglets are weaned. When piglets are born, they are checked twice per day during sow feeding times. Assistance is given when piglets are lying away from the sow and when piglets are not drinking together with littermates. Piglets are either put in the piglet nest or are placed at a teat.

- Tail biting:

Piglet tails are docked without anesthesia at an age of 2 to 5 days to prevent piglets from tail biting in later life. During the tail docking process, piglets also get the necessary injections and an ear tag. With docked tails, tail biting occurs among 1.2% of the weaned piglets (based on (De Lauwere et al., 2009)). After weaning, piglets are housed in groups of 40 piglets, i.e., three to four litters combined. The weaned piglets are housed in pens with a surface of 16 m^2 with a 60% slatted concrete floor and a 40% solid concrete floor. On each side of the pen, a chain is available for enrichment (Figure 5.1b).

- Indoor housing gestating sows:

During the gestation period, until they move to farrowing pens, sows are housed in pens with free access stalls. The period that they are housed in free access stalls is approximately 110 days per reproduction cycle. Because the gestation period is the longest period of a full reproduction cycle of approximately 154 days, we only focus on sow housing in this period. Each pen consists of a 70% solid concrete floor and 30% slatted concrete floor (Figure 5.1c). Sows are fed twice per day in their own feeding trough. There are no windows in the stables, so light intensity is controlled with artificial light for 9 hours per day. Temperatures in the stables are automatically measured and adjusted to 20 °C.

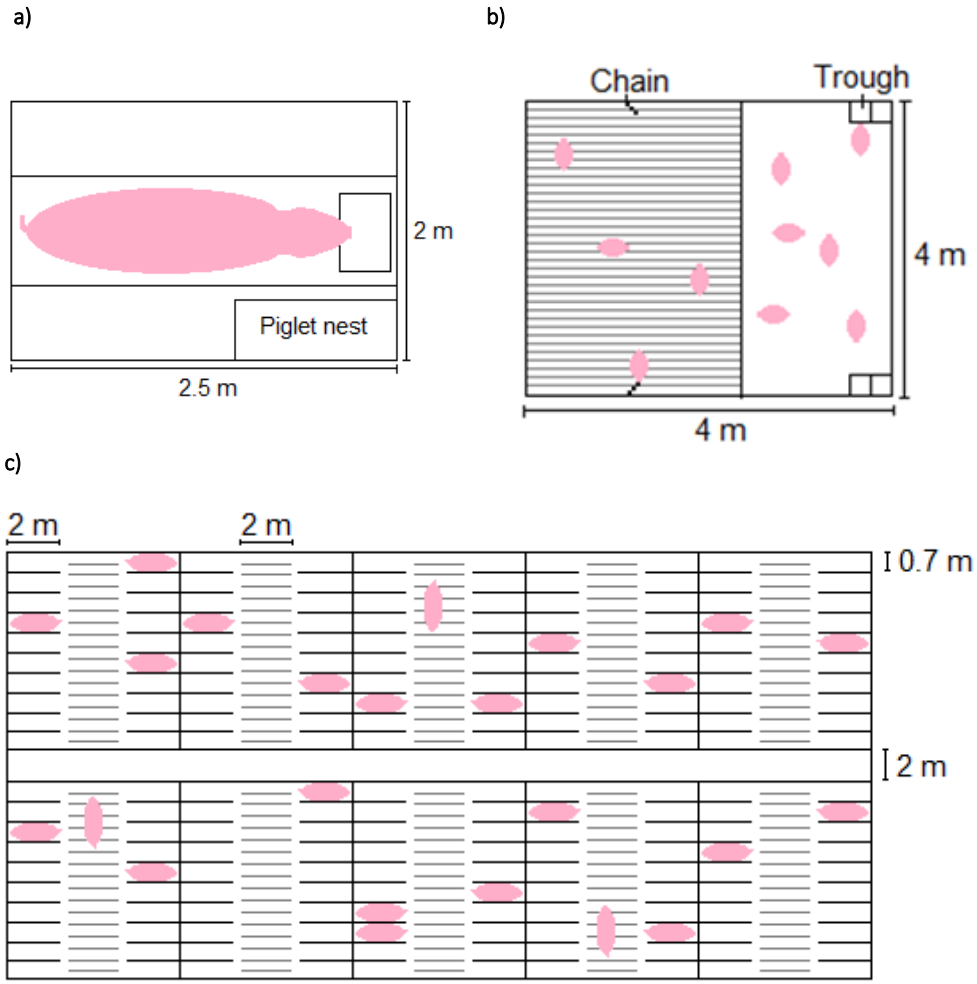

Figure 5.1 Design of the farrowing pen (a), weaned piglet pen (b) and gestating sow pens (c) in the reference sow farm. Grey lines represent slatted floors. The farrowing pen has a fully slatted floor except for the solid floor in the piglet nest.

Measures to improve animal welfare

For each of the three aforementioned animal welfare issues, four measures to improve animal welfare were defined. Criteria for measures were that they can be implemented in the existing reference farm and that they have a positive effect on animal welfare. Based on literature and input of experts in the field of animal welfare and pig economics, measures were selected.

The defined measures to reduce piglet mortality (PM):

- PM1: Camera surveillance farrowing pen

An important reason for piglet mortality is insufficient colostrum intake in the first 48 hours after parturition (Dyck and Swierstra, 1987; Loncke et al., 2009; Rooke and Bland, 2002). To ensure that piglets get sufficient colostrum intake, supervision of the sows and piglets is effective (Holyoake et al., 1995; Loncke et al., 2009).

With measure PM1, surveillance cameras are introduced to improve supervision of the sows and piglets during the first 48 after parturition. With cameras, the sows do not get agitated by the presence of the farmer. Agitation in sows can have negative side effects, such as crushing piglets (Loncke et al., 2009; Weary et al., 1996). When necessary the farmer will go inside the stables to offer assistance. The sows and piglets are monitored by camera every hour (from 7.30 AM until 9.30 PM) so that the farmer has the possibility to notice problems sooner than in the current practice of monitoring twice daily. One camera has the capacity to record two farrowing pens. Hence, each round (every week) 10 cameras will be in use to monitor the sows that farrow that week. Investments exist of the cameras and a monitor.

- PM2: Jute sack provision sow

Nesting behavior of sows has a positive effect on piglet survival (Andersen et al., 2005; Barnett et al., 2001a). Sows that have the possibility to express nesting behavior just before parturition have a lower chance of crushing piglets than sows that do not have this possibility (Pedersen et al., 2006). A material that may be used to stimulate nesting behavior of sows is a jute sack. It has been shown that giving sows one jute sack decreases piglet mortality with 0.4% (Hoofs, 2012). With two jute sacks this is even 0.8% (Hoofs, 2012).

Because of the positive effect of the use of two jute sacks, measure PM2 introduces two jute sacks to sows from the moment they are in the farrowing pen. These jute sacks are put in a sack holder that is attached to the farrowing pen at a height of 30 cm close to the head of the sow. The jute sacks stay in the sack holder until piglets are weaned.

- PM3: Straw provision sow

Providing straw to the sow increases both nesting and maternal behavior (Herskin et al., 1998; Pedersen et al., 2003). As explained under PM2, nesting behavior has a positive effect on piglet survival. The increase of maternal behavior increases reactivity on piglets (Herskin et al., 1998). Consequently, sows show less dangerous lying down activities which decreases piglet crushing (Marchant et al., 2001). Besides that, piglets from sows with nesting material need less time to suckle for the first time then piglets from sows without nesting material (Pedersen et al., 2003). This results in higher colostrum intake.

Measure PM3 provides sows in farrowing pens with 300 grams of straw in the feeding trough half a day before farrowing. To prevent straw from falling in the manure drain, the slatted floor element of the front part of the pen is replaced by a solid floor element.

- PM4: Sow habituation

When sows are fearful of humans, interactions with humans may induce a stress response (Hemsworth et al., 1993). Stress responses can result in lower productivity in terms of numbers of live piglets (Hemsworth et al., 1993). Positive experiences with being handled by humans results in a lower stress response in sows (Boivin et al., 2003; Hemsworth et al., 1985).

With measure PM4, sows for reproduction that newly arrive at the farm are habituated to get used to human handling. During a habituation period of one week, the farmer spends two times per day two minutes with the new sow. The sow is gently touched by the farmer at different body parts and the farmer talks to her with a calm voice. At random the farmer gives the sow some pellets in a feeding trough or on the floor as a reward. After the habituation period the farmer has to maintain positive interactions with the sows, for example, by touching the sows every now and then when walking through the pens.

The defined measures to prevent tail biting (TB):

- TB1: Tail docking with analgesia

Preoperative analgesic administration in tail docking results in a shorter recovery time (Swindle, 2008). For surgical procedures it is recommended to use nonsteroidal anti-inflammatory drugs (NSAIDs; Swindle, 2008). NSAIDs inhibit prostaglandin production, which cause inflammation, pain, exudation (leaking fluid from blood vessels) and fever (EMA, 2014).

With measure TB1 piglets get an intradermal injection of NSAID at least 30 minutes before their tails are being docked. In the Netherlands this injection can be given by the pig farmer self after prescription of a veterinarian. Piglets get injected without needles.

- TB2: Biting material for weaned piglets

One of the reasons piglets bite each other's tails is disharmony between piglets and their environment (Schrøder-Petersen and Simonsen, 2001). Environmental enrichment, e.g. biting material, stimulates piglet's play behavior which reduces the risk of harmful social behavior, such as tail biting (Beattie et al., 2000; Beattie et al., 1995). It is important to keep the environmental enrichment interesting for piglets to prevent them from losing interest (Bracke et al., 2007; Van de Weerd et al., 2005).

With measure TB2, piglet tails are not docked. Instead, weaned piglets get environmental enrichment that will be replaced every day. Each pen receives two different enrichment

materials that are provided in random order. In each pen two distance holders will be connected at a height of 100 cm which ensures that enrichment objects can, if necessary, be placed inside the pen at a distance of 20 cm from the wall. Five enrichment objects were selected based on their positive effect on animal welfare (Bracke et al., 1998; Zonderland, 2007): chain, chain with wood, bobbin with rope, chain with rubber and plastic ball. Tail biting occurs more often among piglets with tails and provision of biting material compared to piglets with docked tails (Zonderland et al., 2008 a). Zonderland et al. (2008) showed that approximately 55% of piglets had bite wounds on their tails when biting material was provided, that is when a single object was offered for a longer period of time. We assumed that measure TB2 will result in tail bite wounds among 30% of the piglets.

- TB3: Straw playing area for weaned piglets

Similar to biting material provision (TB2), the social behavior of piglets will be improved by providing substrates such as straw (O'Connell and Beattie, 1999). With access to straw, the risk of tail biting decreases (Guy et al., 2002; Moinard et al., 2003). The risk of tail biting is even lower with access to straw than with access to biting material (Bracke et al., 1998; Van de Weerd et al., 2005).

Similar to TB2, with measure TB3 piglet tails are not docked. Instead weaned piglets are provided with a straw playing area that occupies the solid concrete floor. A bar on the floor will separate the playing area from the rest of the pen. Every six weeks, when pens are cleaned, straw will be replaced by 5 kg fresh straw. Every day 10 gr of fresh straw per animal will be added. It is assumed that tail bite wounds occur among 20% of the piglets after introduction of this measure.

- TB4: Chopped straw provision for weaned piglets

Similar to biting material (TB2) and straw playing area (TB3) provision, providing piglets with a small amount of straw twice per day decreases the risk of tail biting (Hunter et al., 2001; Zonderland et al., 2008 a). It may even have a better effect than providing deep straw (Hunter et al., 2001).

Similar to TB2 and TB3, with measure TB4 piglet tails are not docked. Instead piglets are provided with 10 gram chopped straw per piglet two times per day. The straw will be eaten by piglets and is finished well before the next portion will be provided. This will keep straw interesting for the piglets. After the introduction of this measure, tail bite wounds are assumed to occur among 10% of the piglets (based on Zonderland et al., 2008 a).

Defined measures to improve indoor housing (IH) of gestating sows:

- IH1: Free range outside area

An outside area gives sows more space, environmental enrichment and fresh air, what will have a positive effect on sow welfare (Anon, 1996; Edwards, 2005). Being able to go outside will give animals increased environmental diversity and the possibility to express (more) natural behaviors (Edwards, 2005).

With measure IH1, each sow pen gets a passage in the outside wall of 3 m wide and 1.5 m high to an outside area. The opening will be covered with rubber flaps to control the indoor temperature. The opening gives sows free access outside. The outdoor surface will be 42 m^2 and will exist of a sand bedding. To prepare the outside surface the floor will be excavated and filled with white sand. The sand area will be fenced with an iron fence.

- IH2: Straw provision

A straw bed in sow pens has a positive effect on sow welfare and behavior (Guy et al., 2002; Tuyttens, 2005). Straw gives sows the opportunity to express behavior patterns such as rooting, exploring and foraging (Tuyttens, 2005).

With measure IH2, each sow receives 100 grams of straw daily.

- IH3: Straw provision and daylight

It is expected that daylight has a positive effect on the welfare and health of sows as well as a positive effect on the welfare of the farmer (Winkel and Bokma, 2011; Zonderland et al., 2008 b).

With measure IH3, additional to straw provision as described under IH2, each pen gets an insulated glass window in the outside wall. The window will be 2 m wide and 1 m high.

- IH4: Straw provision, daylight and increased group size

Stable groups have a clear social order resulting in calmer groups (Van der Peet-Schwering et al., 2010). It is expected that in larger groups the space needed per animal is lower (Van der Peet-Schwering et al., 2010). Increasing group sizes results in less labor and in more efficient building usage (Turner et al., 2003). With an increased group size, the week system changes from an one-week system to a several-week system. A several-week system has the advantage that labor can be divided more efficient because activities are divided over weeks instead of several activities within one week (Van der Peet-Schwering et al., 2010).

With measure IH4, group sizes change from 20 to 100 sows per group. As a result the one-week system changes into a five-week system. One group of sows farrow at the same time which means that all farrowing pens are occupied by one group. As groups become five times bigger, five pens will be transformed into one bigger pen. In the pens all free access stalls will be removed and the feeding system will be changed from separate feeding troughs into an electronic sow feeding system. Each pen receives two electronic feeders

and ten drinking spots. Each day 100 gr of straw per sow will be distributed. Besides straw, each pen will get an insulated glass window in the outside wall. A window will be 4 m wide and 1 m high.

The animal welfare and economics model

To compare policies in their effects on economics and animal welfare, first the differences in effects compared to the reference sow farm had to be calculated. To calculate these effects, a simulation model was developed; the animal-welfare-economics (WelEc) model. This model exists of two modules to calculate outputs; the economic module and the animal welfare module.

The economic module of WelEc defined a calculation method for net farm income per farm per year $\mathrm{NFI} = \mathrm{TRE} - \mathrm{TCO}$, where TRE refers to total returns and TCO refers to total costs. The total returns were calculated by $\mathrm{TRE} = \mathrm{PP} * \mathrm{NL} * (\mathrm{LZ} - \mathrm{LZ} * \mathrm{PM}) + \mathrm{SS} * \mathrm{RS} / (100\% - \mathrm{SB}) + \mathrm{SP} * (\mathrm{RS} - \mathrm{SB})$, where PP was price piglet, NL was number of litters, LZ was litter size, PM was piglet mortality, SS was selected breeding sow price, RS was replacement breeding sows, SB was selection breeding sow before first insemination and SP was sow price. The total costs were calculated by $\mathrm{TCO} = \sum(\mathrm{TBC\ TAC\ TFC\ TLC\ TOC})$, where TBC was total building costs, TAC was total animal costs, TFC was total feed costs, TLC was total labor costs and TOC was total other costs. The total building costs were calculated by $\mathrm{TBC} = \mathrm{IB} * \mathrm{CS} / \mathrm{OP} * \mathrm{CS} / \mathrm{DI} + \mathrm{IB} * \mathrm{CS} / \mathrm{OP} * \mathrm{CS} * \mathrm{MI}$, where IB was investment building and inventory, CS was company size, OP was occupation (percentage sows regarding sow places), DI was depreciation period investment and MI was market interest. The total animal costs were calculated by $\mathrm{TAC} = \mathrm{BP} * (\mathrm{RS}/(100\% - \mathrm{SB})) + (\mathrm{SP} + (\mathrm{SP} + \mathrm{LZ} * (1 - \mathrm{PM}) * \mathrm{PP}) / 2) * \mathrm{MI}$, where BP was breeding sow price. The total feed costs were calculated by $\mathrm{TFC} = \mathrm{SF} / 100 * \mathrm{SI} + \mathrm{PF} / 100 * \mathrm{PI} * \mathrm{NL} * (\mathrm{LZ} - \mathrm{LZ} * \mathrm{PM}) + (\mathrm{SF} / 100 * \mathrm{SI} + \mathrm{PF} / 100 * \mathrm{PI} * \mathrm{NL} * (\mathrm{LZ} - \mathrm{LZ} * \mathrm{PM})) * \mathrm{MI} / 52$, where SF was sow feed price, SI was sow feed intake, PF was piglet feed price and PI was piglet feed intake. The total labor costs were calculated by $\mathrm{TLC} = \mathrm{CS} * \mathrm{OP} * \sum(\mathrm{CP\ CF\ CA\ CW\ TD\ CC\ OT}) * \mathrm{LP}$, where CP was time to clean sow pens, CF was time to clean farrowing pens, CA was time to clean farrowing pens after weaning, CW was time to clean weaned piglet pens, TD was time to dock piglet tails, CC was time to check piglets in the first 48 hours, OT was time for other tasks and LP was labor price. Total other costs were calculated by $\mathrm{TOC} = \sum(\mathrm{HC\ TC\ HE\ LI\ PA\ CA\ JS\ ST\ EE\ AN\ OC})$, where HC was health care costs, TC was

transport costs piglets, HE was heating costs, LI was lighting costs, PA was pen adjustment costs, CA was camera costs, JS was jute sack costs, ST was straw costs, EE was environmental enrichment costs, AN was analgesia costs and OC was other costs.

The animal welfare module of WelEc consisted of a calculation method for a total animal welfare score per farm $\mathrm{TAWS}_i = \sum_{i=1}^{\mathrm{n}}(\mathrm{AWS}_i)$, where AWS_i refers to the animal welfare score for animal welfare feature i of the total number of animal welfare features n. The n animal welfare features for WelEc were based on Welfare Quality® (Blokhuis, 2008; Botreau et al., 2007). Welfare Quality® was developed for the assessment of the welfare of cattle, poultry and pigs in terms of behavior, health, performance and disease-resistance (Blokhuis, 2008; Botreau et al., 2007). Welfare Quality® includes 12 criteria with different animal welfare features (Blokhuis, 2008). From these criteria and features, only those that were relevant for the measures defined in our study were implemented in WelEc. Because Welfare Quality® does not focus on piglet welfare, features for piglet welfare were added to WelEc. All criteria and features that are used in WelEc are shown in Table 5.2. For each of the defined features, parameters were defined or copied from Welfare Quality® (Table 5.2). Based on scores for the feature parameters, animal welfare scores were calculated on a scale of 0 (worst for animal welfare) to 100 (best for animal welfare). Although the features and parameters were based on Welfare Quality®, the animal welfare score calculations were not similar to Welfare Quality®. For WelEc we formulated separate formulas. The features water supply (WS) and number of clean drinking spots (CD) were combined to an animal welfare score for water supply $\mathrm{AWSW} = 100/\mathrm{WS} * \mathrm{CD}$. The animal welfare score for number of sows per drinking spot was calculated with $\mathrm{AWSD} = 1/(\mathrm{PD} * \mathrm{n}a) * 100$, where $\mathrm{n}a$ is the number of animals per drinking nipple and PD is the expected percentage of animals per drinking nipple that have drinking needs at the same time. For feature parameters with two categories, i.e., stereotypies sow (Table 5.2), the percentage for category '0' was the animal welfare score. For all feature parameters with three categories, such as bursitis and lameness sow, the animal welfare score was calculated with $\mathrm{AWSX} = \mathrm{C0} - \mathrm{C2}/10/2$, where $\mathrm{C0}$ was the percentage assigned to category '0' and $\mathrm{C2}$ was the percentage assigned to category '2'. The percentage assigned to the features mortality and explorative behavior was also the animal welfare score. The percentage assigned to the features mortality and positive social behavior was subtracted from 100 to become animal welfare scores. The animal welfare score for surface per sow was calculated by $\mathrm{AWSS} = (\mathrm{F}_s - m)/\mathrm{F}_s * 100$, where F_s refers to feature score for surface per sow and m is the legal minimum surface, which is 2.1 m^2 in the Netherlands. For group size it was assumed that ≥100 animals per group was optimal for animal welfare, meaning that the number of animals per group till 100 is the animal welfare score and groups of 100 or more

Table 5.2 Animal welfare features per criterion of the animal welfare module of WelEc and the feature scores of the default situation.

Criterion	Feature	Parameter	Score default
Absence of prolonged thirst	Water supply	Number of drinking nipples for sows	400
	Number of clean drinking spots	Number of clean drinking nipples for sows	350
	Number of sows per drinking spot	Number of sows per drinking spot	1
Comfort around resting	Bursitis	0 = no lump, 1 = lump in size of walnut, 2 = lump in size of tangerine	0: 60%, 1: 40%
	Absence manure on body sow	0 = <10% manure, 1 = 10-30%, 2 = >30%	0: 70%, 1: 20%, 2: 10%
	Absence manure on body piglet	0 = <10% manure, 1 = 10-30%, 2 = >30%	0: 70%, 1: 20%, 2: 10%
	Shoulder sores sow	0 = whole, 1 = old wound, 2 = fresh wound	0: 95%, 1: 4%, 2: 1%
Ease of movement	Surface per sow	Square meters per sow	2.4
	Group size	Number of pregnant sows per pen	20
Absence of injuries	Lameness sow	0 = not lame, 1 = moderately lame (1 leg relieved), 2 = seriously lame (1 leg not used)	0:90%, 1:10%
	Lameness piglet	0 = not lame, 1 = moderately lame (1 leg relieved), 2 = seriously lame (1 leg not used)	0:90%, 1:10%
	Body wounds sow	0 = no scratches, 1 = small scratches, 2 = serious scratches	0: 80%, 1: 15%, 2: 5%
	Body wounds piglet	0 = no biting wounds, 1 = superfisial biting wounds, 2 = serious biting wounds that need care	0: 98.8%, 1: 0.5%, 2: 0.7%
	Vulva lesions sow	0 = no wound or scar on vulva, 1 = crust or scar > 2 cm, 2 = fresh wound	0: 90%, 1: 8%, 2: 2%
Absence of disease	Mortality sow	Percentage sows that died in the stables	5%
	Mortality piglet	Percentage piglets that died	13%
Absence pain induced by management procedures	Tail docking	0 = no tail docking, 1 = tail docking with sedation/analgesia, 2 = tail docking without sedation	2: 100%
Expression of social behaviors	Positive social behavior sow	Percentage snifs/liks without walking away of total behavior observations, five intervals of 2 min	3.00%
	Positive social behavior piglet	Percentage snifs/liks without walking away of total behavior observations, five intervals of 2 min	8.00%
	Negative social behavior sow	Percentage aggression with reaction of total behavior observations, five intervals of 2 min	5.00%
	Negative social behavior piglet	Percentage aggression with reaction of total behavior observations, five intervals of 2 min	12.00%
Expression of other behaviors	Stereotypies sow	0 = no stereotypies within 15 seconds (s), 1 = stereotypies within 15 s	0: 60%, 1: 40%
	Explorative behavior sow	Percentage exploration of total behavior observations during five intervals of 2 min	48%
	Explorative behavior piglet	Percentage exploration of total behavior observations during five intervals of 2 min	52%
Good human-animal relationship	Human-animal relation score sow	0 = touch head 10 s, 1 = walks away when touching, 2 = walks away within 10 s after entering pen	0: 18%, 1: 56%, 2: 26%
	Human-animal relation score piglet	0 = touch head 10 s, 1 = walks away when touching, 2 = walks away within 10 s after entering pen	0: 5%, 1: 34%, 2: 61%
Absence of general fear	Qualitative Behavioral Assessment (QBA) score sow	Sum of scores (0-125) for active, relaxed, fearful, agitated, quit, satisfied, tense, enjoying, frustrated, social, bored, lively, indifferent, irritated, aimless, happy, sad.	-5
	Qualitative Behavioral Assessment (QBA) score piglet	Sum of scores (0-125) for active, relaxed, fearful, agitated, quit, satisfied, tense, enjoying, frustrated, social, bored, lively, indifferent, irritated, aimless, happy, sad.	-5

Sources: Criteria, features and parameters based on Welfare Quality® (2009), feature scores based on Vermeer (2012)

animals is 100%. Tail docking received an animal welfare score of 0 when tails were docked without sedation, a score of 25 when tails were docked with either preoperative or postoperative analgesia, a score of 50 when tails were docked with both pre- and postoperative analgesia and a score of 100 when tails were not docked. The qualitative behavioral assessment score could receive a feature score between -8 and 8, which is a range of 16. For the animal welfare score of the qualitative behavioral assessment score, the percentage of the feature score on the 16 scale was used. For example, a feature score of -5 would be a score of 3 on the 16 scale which is 18.8% and thus an animal welfare score of 18.8.

Parameterization

The inputs for the economic module of WelEc were selected based on relevance for the defined measures. For the reference farm, default values were assigned to each input. These values were obtained in several ways. Some of the inputs were based on literature. The technical numbers were obtained from a handbook (KWIN-Veehouderij, 2013/2014) and a summary of pig sector statistics (Agrovision b.v., 2012). A conventional sow farmer with a sow farm similar to the reference sow farm was selected from a list of pig farmers who participated in a program where farmers open their farm to the public (Stap in de stal, 2014). The selected sow farm was visited for information and an in depth-interview with the farmer. Based on the knowledge and experience of the sow farmer it was possible to, for example, indicate the amount of labor necessary for different tasks. For the few inputs that could not be valued using external information, assumptions were made based upon our own expertise.
For each defined measure for animal welfare improvement, the inputs that will be affected were determined. For each affected input, the effect relative to the default situation was calculated. The calculations were carried out using numbers from literature, experts input and numbers given by companies selling products and equipment needed for the defined measures. The economic inputs for the default situation as well as the changes of input for the defined measures are shown in Table 5.3. Appendix 5.1 provides a description of changing inputs.

For the animal welfare module, default scores were assigned to the feature parameters for the reference farm (Table 5.2) based on average scores for a sow farm in the Netherlands (Vermeer et al., 2012). For each measure, the parameter scores that will be affected were determined. The changing parameter scores per measure are shown in Appendix 5.2.

Based on these scores, animal welfare scores were calculated for each measure. The animal welfare scores per feature for the default situation and the animal welfare scores that change per animal welfare improvement measure for sow husbandry are shown in Table 5.4. The animal welfare score for water supply only changed for measure IH4, where the number of available drinking nipples per animal changed from 1:1 to 10:1. It is shown that pigs usually start drinking after eating and consume 30% of their daily water intake (Yang et al., 1981). Based on this finding and the availability of two feeding troughs and ten drinking nipples, we assumed the percentage of animals per drinking nipple that have drinking needs at the same time to be 13%.

Model application and sensitivity analysis

To present the outputs of both modules of WelEc, results of the default situation and after implementation of each measure were listed. To compare measures in their effects on economics and animal welfare, cost-effectiveness ratios were calculated as $\mathrm{R}_i = \Delta\mathrm{NFI}_i/\Delta\mathrm{AWS}_i$, where $\Delta\mathrm{NFI}_i$ was the difference in net farm income between measure i and the default situation and $\Delta\mathrm{AWS}_i$ was the difference in animal welfare score between measure i and the default situation. Based on the cost-effectiveness ratios it was possible to rank the measures; rank 1 was for the measure with the highest cost-effectiveness ratio, rank 2 was for the measure with the second highest cost-effectiveness ratio, and so on. The measure effects on net farm income (€/year) and on animal welfare scores (% improvement) relative to the default situation were plotted. Percentages of animal welfare improvement were calculated as $\mathrm{AWI} = \mathrm{TWS}i/\mathrm{MAW} * 100 - \mathrm{TWS}d/\mathrm{MAW} * 100$, where TWS was the total animal welfare score of measure i or the default situation d and MAW was the maximum possible animal welfare score, which was 2700.

A sensitivity analysis was carried out to test the sensitivity of the outcomes for the estimated effects of the measures. For the sensitivity analysis, per measure all the inputs for the economic and animal welfare module that changed were either increased or decreased altogether with 5%. For each measure the cost-effectiveness ratio was calculated for a situation with increased inputs and for a situation with decreased inputs. For both the increased and the decreased inputs, measures were ranked based on the cost-effectiveness ratios. These rankings were compared to the ranking of the original cost-effectiveness ratios to determine sensitivity.

Table 5.3 Inputs for the economic module of WelEc for the default situation and the affected inputs per measure to reduce piglet mortality (PM), to prevent tail biting (TB) and to improve indoor housing (IH) (see Appendix 5.1 for a detailed description of inputs).

		Input	Adjusted inputs per measure											
Input name	Unit	DF	PM1[a]	PM2	PM3	PM4	TB1	Tb2	TB3	TB4	IH1	IH2	IH3	IH4
Technical numbers														
Company size	sow places	440	[b]											
Occupation (sows/sow places)	percent	91												
Number of litters	sow/year	2.36												
Litter size	live piglets/litter	13.8												
Piglet mortality	percent	13	12.00	12.20	12.40	12.40								
Replacement breeding sows	percent	43												
Selection sow before first insemination	percent	5												
Sow feed intake	kg/sow/year	1165	1178.57	1175.69	1173.22	1173.22								
Piglet feed intake	kg/piglet	28.2												
Buildings and inventory														
Investment building and inventory	€/sow place	2500												
Depreciation period investment	year	20												
Market interest	percent	6												
Maintenance	percent investment	1.5												
Prices														
Sow price	€/sow	163												
Breeding sow price	€/sow	250												
Selected breeding sow price	€/sow	121.2												
Sow feed	€/100 kg	23.5												
Piglet price (25 kg)	€/piglet	43												
Piglet feed	€/100 kg	35												
Labour	€/hour	22.85												
Other costs														
Health care	€/sow/year	69						70.13	69.85	69.80	62.10	64.17	64.86	62.79
Transport costs piglets	€/piglet	27												
Heating	€/sow/year	29												
Lighting	€/sow/year	2.7											1.76	1.76
Pen adjustments (e.g. floor and wall)	€/sow/year	0			0.67				0.33		7.31		2.50	12.74
Cameras	€/sow/year	0	1.77											
Jute bag	€/sow/year	0		4.33										

Straw	€/sow/year	0			0.08				2.58	0.27		3.99	3.99	3.99
Environmental enrichment	€/sow/year	0						0.85						
Analgesia	€/sow/year	0					1.45							
Other costs (e.g. water)	€/sow/year	60												
Time management														
Time cleaning sow pen	hours/sow/year	0.30									0.45	0.38	0.38	0.08
Time cleaning farrowing pen	hours/sow/year	0.23												
Time cleaning farrowing pen after weaning	hours/sow/year	3.22												
Time cleaning weaned piglet pen	hours/sow/year	0.18												
Time tail docking	hours/sow/year	0.92												
Time checks piglets first 48 hours	hours/sow/year	0.30	0.36											
Time other tasks	hours/sow/year	5.22		5.25	5.22	5.32	5.31	5.46	5.37	5.37		5.37	5.37	

[a] Explanation abbreviations: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increase group size.

[b] When no value is given the same value as in the default situation was assumed.

Sources: Agrovision (2012), KWIN-Veehouderij (2013/2014) and an in-depth interview with a farmer owning a sow farm comparable to the reference sow farm.

Table 5.4 Animal welfare score (AWS) per feature of the animal welfare module of WelEc for the default situation and the affected AWS per measure to reduce piglet mortality (PM), to prevent tail biting (TB) and to improve indoor housing (IH).

	AWS[a]	Affected AWS per measure											
Feature	**Default**	*PM1*[b]	*PM2*	*PM3*	*PM4*	*TB1*	*TB2*	*TB3*	*TB4*	*IH1*	*IH2*	*IH3*	*IH4*
Water supply	**87.5**	[c]											95
No. sows per drinking spot	**100**												10
Bursitis	**60**									80	75	75	75
Absence manure on body sow	**65**									79.7	76.7	76.7	76.7
Absence manure on body piglet	**65**							79.8	79.8				
Shoulder sores sow	**95**			98									
Surface per sow	**12.5**									53.3			
Group size	**20**												100
Lameness sow	**90**									95	95	95	95
Lameness piglet	**90**						95	91	95				
Body wounds sow	**77.5**									89.9	84.9	84.9	89.9
Body wounds piglet	**98.5**						79.8	85.9	87.9				
Vulva lesions sow	**89**									98	98	98	94.9
Mortality sow	**95**									97			
Mortality piglet	**87**	88.0	87.8	87.6	87.6								
Tail docking	**0**					25	100	100	100				
Positive social behaviour sow	**3**				4.0					6	4	4	5
Positive social behaviour piglet	**8**							12	9				
Negative social behaviour sow	**95**				96					98	96	96	97
Negative social behaviour piglet	**88**						90	92	90				
Stereotypies sow	**60**									65	90	90	92
Explorative behaviour sow	**48**		60	60						80	70	70	80
Explorative behaviour piglet	**52**						70	28	13				
Human-animal relation score sow	**16.7**				74.8					49.1	38.8	35.8	52.2
Human-animal relation score piglet	**2**						7.5	13.8	18				
Qualitative Behavioural Assessment (QBA) score sow	**18.8**		30.3	30.3	30.3					62.6	56.3	56.3	62.6
Qualitative Behavioural Assessment (QBA) score piglet	**18.8**						43.8	56.3	43.8				

[a] Animal welfare scores were given on a scale of 1 (worst for animal welfare) to 100 (best for animal welfare).

[b] Explanation abbreviations: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increase group size.

[c] When no value is given the same value as in the default situation was assumed.

5.3 Results

The net farm income and animal welfare scores for the default situation and after implementation of each measure were calculated with the WelEc model. These results are shown in Table 5.5. The measures for piglet mortality (PM) had a positive effect on net farm income. These measures showed the highest cost-effectiveness ratios, indicating effectiveness based on net farm income and animal welfare score, compared to the other measures. Measure PM1 (camera surveillance farrowing pen) had a cost-effectiveness ratio of 1700 (i.e., an increase of €1700 net farm income for an animal welfare score increase of 1) which was the highest of all ratios. The PM measures were the only measures with an effect on animal and feed costs and on total returns. These measures had a relatively low effect on animal welfare with an animal welfare improvement of maximum 2.7% compared to the default situation (Figure 5.2). The highest effect on animal welfare compared to the other measures was that of measure IH4 (straw provision, daylight and increased group size) with an animal welfare improvement of 9.4% with regard to the default situation (Figure 5.2). This
measure had a negative effect on total net farm income, i.e., a decrease of €1,773 per year relative to the default situation, but was the only measure with a decrease in total labor costs (Figure 5.2). Of the measures with a negative effect on net farm income, measure IH4 and IH1 (free range outside area) had the highest cost-effectiveness ratio with a ratio of -7 (Table 5.5). The effects on net farm income of measure TB1(tail docking with analgesia), TB4 (chopped straw provision for weaned piglets) and IH2 (straw provision) were comparable to the effects of IH1 and IH4. Measure TB4, IH1 and IH2 had a relatively high effect on animal welfare, i.e., an improvement between 5.7% and 8% relative to the default situation (Figure 5.2). Measure TB1 had a relatively low effect on animal welfare, i.e., an improvement of 0.9% relative to the default situation (Figure 5.2). This measure had the lowest cost-effectiveness ratio compared to the other measures (Table 5.5). Measure TB3 (straw playing area for weaned piglets) had the highest negative effect on net farm income compared to the other measures, i.e., a decrease of €3,718 per year relative to the default situation (Figure 5.2). The effect of measure TB3 on animal welfare was relatively high, i.e., an improvement of 6.8% relative to the default situation (Figure 5.2). Measure TB2 (biting material for weaned piglets) and IH3 (straw provision and daylight) had a relatively high negative effect on net farm income, i.e., a decrease of €3,041 and €2,638 per year respectively relative to the default situation, and a relatively low effect on animal welfare, i.e., an improvement of 5.1% and 5.6% respectively for TB2 and IH3 relative to the default

situation (Figure 5.2). MeasuresTB2, TB3 and IH3 had, after measure TB1, the lowest cost-effectiveness ratios (Table 5.5).

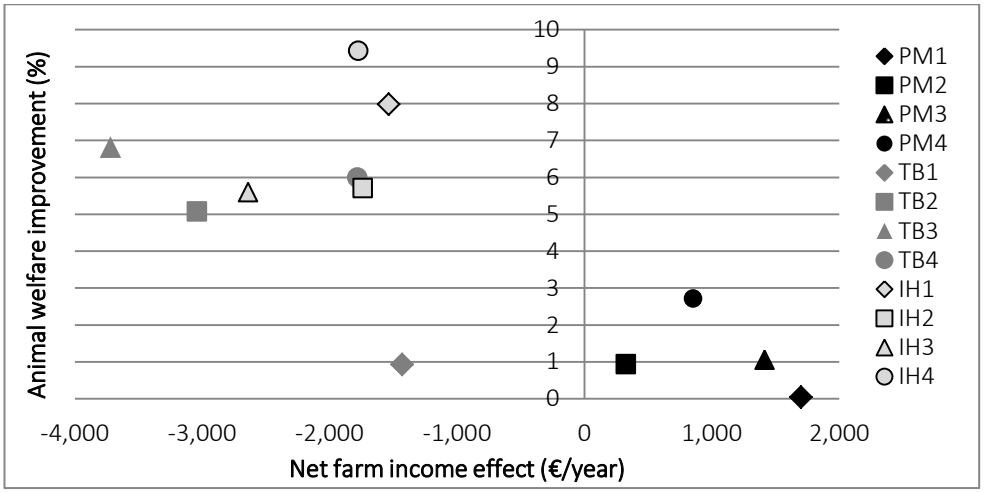

Figure 5.2 The effects of measures to reduce piglet mortality (PM), to prevent tail biting (TB) and to improve indoor housing (IH) on animal welfare and net farm income. Per measure the percentages improvement in animal welfare relative to the default situation are plotted against the increase or decrease in net farm income relative to the default situation.
Explanation abbreviations: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increase group size.

Sensitivity analysis

Cost-effectiveness ratios of the various animal welfare improvement measures were calculated after changing inputs of the WelEc model with a 5% increase and a 5% decrease. These ratios were ranked and compared to the ranking of the original cost-effectiveness ratios (Table 5.6). The ranking in cost-effective ratios did not change after decreasing inputs with 5% compared to the ranking of the original ratios. The ranking of cost-effective ratios after increasing inputs with 5% did show a change in ranking compared to the ranking of the original ratios. Measure TB2 shifted from rank 3 to 11.

Table 5.5 Economic and animal welfare outputs of WelEc for the default situation and the change in outputs relative to the default situation per measures to reduce piglet mortality (PM), to prevent tail biting (TB) and to improve indoor housing (IH).

		Economics (€/year)						Animal welfare	Cost-
Measure[a]	NFI[b]	TIB	TAC	TFC	TLC	TOC	TRE	AWS	Effectiveness[c]
Default	-38177	104500	55,370	221,629	94,818	75,080	513,221	1554.6	
PM1	1702	0	71	2,564	558	707	5,602	1	1702
PM2	327	0	57	2,036	329	1,733	4,481	25	13
PM3	1414	0	43	1,546	60	298	3,361	28	51
PM4	855	0	43	1,546	917	0	3,361	73	12
TB1	-1431	0	0	0	849	582	0	25	-57
TB2	-3041	0	0	0	2,248	794	0	137	-22
TB3	-3718	0	0	0	2,212	1,507	0	184	-20
TB4	-1782	0	0	0	1,389	393	0	161	-11
IH1	-1535	0	0	0	1,371	164	0	215	-7
IH2	-1740	0	0	0	2,075	-335	0	154	-11
IH3	-2638	0	0	0	2,075	563	0	151	-17
IH4	-1773	0	0	0	-2,056	3,830	0	255	-7

[a] Measures: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increase group size.

[b] Explanation abbreviations: NFI: net farm income, TIB: total investment buildings, TAC: total animal costs, TFC: total feed costs, TLC: total labor costs, TOC: total other costs, TRE: total returns, TWS: total animal welfare score.

[c] Cost-effectiveness = $\Delta NFI/\Delta AWS$.

Table 5.6 Cost-effectiveness (C-E) and ranking of the measures to reduce piglet mortality (PM), to prevent tail biting (TB) and to improve indoor housing (IH). Ranking is based on the C-E. Values are given for the original (most likely) model inputs as well as for an increase and decrease of 5% in model inputs.

Measure*	C-E original	C-E 5% increase	C-E 5% decrease	Rank original	Rank 5% increase	Rank 5% decrease
PM1	1702	91	6494	1	1	1
PM3	49	-2	124	2	2	2
PM2	13	-43	84	3	11	3
PM4	12	-8	34	4	3	4
IH4	-7	-7	-6	5	4	5
IH1	-7	-8	-6	6	5	6
TB4	-11	-10	-12	7	6	7
IH2	-11	-11	-13	8	7	8
IH3	-17	-15	-19	9	8	9
TB3	-20	-19	-21	10	9	10
TB2	-22	-21	-23	11	10	11
TB1	-57	-60	-54	12	12	12

* Measures: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increase group size.

5.4 Discussion

The objective of this study was to determine the effects of different measures for sow husbandry on animal welfare and economics at farm level. To our knowledge, such work has not been done before. The selected measures were related to three issues of sow husbandry, that are: piglet mortality, tail biting and indoor housing, and were based on the study of Bergstra et al. (2013) which indicated that these issues are important for citizens. This study also indicated that the use of antibiotics is an important issue (Bergstra et al., 2013). This issue was not included in the present study because the Dutch government already put a lot of pressure on the sector to decrease the use of antibiotics.

To calculate the effects of measures related to the aforementioned issues, a simulation model (WelEc) was developed. As with most normative modeling, parameterization for this study was difficult because of the assumptions that had to be made. The assumptions for this study were made with care. For inputs we made use of several resources, i.e., literature, knowledge of experts from different fields and information from companies that sell products necessary for the defined measures. Only the single measure effects were calculated because it is already a challenge to give inputs for single effects, let alone for a combination of several measure effects. Although we based the animal welfare module of WelEc on Welfare Quality®, the calculations were not similar to those used in Welfare Quality®. Welfare Quality® uses complicated not yet approved formulas to calculate a score that includes all features (Welfare Quality®, 2009). That WelEc does not include all features of Welfare Quality® and includes additional features made it impossible to use the Welfare Quality® calculations. The animal welfare scores in WelEc were calculated without giving features an importance weight with regard to animal welfare. Welfare Quality® does include this type of weight, but there is a lot of discussion about the value of these weights. Besides that these discussions make it difficult to assign animal welfare weights to animal welfare features, it was not the aim of this study to discuss these weightings.

Results of the sensitivity analysis showed that the ranking of measures did not change when changes in input values were reduced with 5%. Only the rank of the measure 'jute sack provision sow' changed when input values were increased with 5%. The cost-effectiveness strongly decreased relative to the other measures when the input values were higher. This effect may be the result of the relatively high costs of jute sacks in combination with the increase in piglet mortality, which are both relatively strong affected by an increase of 5%. However, the order of rankings of the other measures remained the same, indicating that overall the results were quite robust.

Results of our study show that measures for sow husbandry have different effects on animal welfare and net farm income. Higher animal welfare did not necessarily result in a lower net farm income. These results coincide with results of other studies on different farm animals. Bruijnis et al. (2013) showed that some relatively costly measures to improve cow foot health had low animal welfare benefits. Stott et al. (2012) showed that the correlation between overall sheep welfare and gross margin was, although positive, not significant. Cain and Guy (2006) indicated that of different housing systems for breeding sows, the outdoor system scored highest in welfare and had the lowest total production costs compared to indoor systems.

The defined measures for piglet mortality were the most cost-effective of all defined measures. This is quite logical because these measures were the only measures with a positive effect on net farm income. This positive effect is the result of a decrease in piglet mortality and, thus, an increase in total returns because of a higher number of piglets to sell. The decrease in piglet mortality and the positive effect of the measure on the sow resulted in an increase in animal welfare. The positive effect on both animal welfare and economics, benefits both the farmer and the animal. However, the increases in animal welfare and net farm income were relatively low. In addition, piglet prices can fluctuate (Pietola and Wang, 2000) and can affect the effects of piglet mortality measures on net farm income. The effects of piglet mortality measures on animal welfare was low compared to the other measures. The lower animal welfare effect can be explained by the fact that piglet mortality measures only have an effect on animal welfare during the farrowing period. As the farrowing period is only a small period of the sow's reproduction cycle, the overall animal welfare effect is small. The measure with the highest effect on animal welfare was de measure 'straw provision, daylight and increased group size' for gestating sows. This animal welfare effect is mainly due to an improvement in sow behavior. Larger groups result in calmer behavior in sows (Van der Peet-Schwering et al., 2010) and a larger surface area gives sows the possibility to avoid conspecifics which has a positive effect on social behavior (Gonyou, 2001). The aforementioned measure was the only measure with a positive effect on labor requirements. This positive effect is the result of the increase in group sizes and a change of pens. Bigger groups and pens makes it possible to work more efficiently (Turner et al., 2003). Adjusting the pens will have a relatively strong effect on total other costs compared to the other measures. The highest costs are in the change of feeding system into an electronic sow feeding system. The measure 'straw provision, daylight and increased group size' and the measure 'free range outside area' for gestating sows had the highest cost-effectiveness of all measures with a negative effect on net farm income. Therewith, these measures had relatively the highest effect on animal welfare with

the lowest costs. The measure 'free range outside area' had a lower effect on net farm income and animal welfare compared to the measure 'straw provision, daylight and increased group size'. The lower effect on total animal welfare is probably because of the lack of straw in the measure 'free range outside area'. Straw gives sows the possibility to express natural behavior and has a positive effect on animal welfare (Tuyttens, 2005). The lower effect on net farm income is a result of lower investment costs than the measure 'straw provision, daylight and increased group size' and no straw costs. With their relatively high effect on animal welfare and a relatively low negative effect on net farm income, the measures 'free range outside area' and 'straw provision, daylight and increased group size' would be interesting to implement for animal welfare improvement. The least interesting to implement would be the measures 'tail docking with analgesia', 'biting material for weaned piglets', 'straw playing area for weaned piglets' and 'straw provision and daylight' because of their relatively high negative effect on net farm income or relatively low effect on animal welfare.

The WelEc model can be used to compare different measures for sow husbandry in their effect on economics and their effect on animal welfare. The inputs of WelEc can easily be adjusted for different default situations and/or different measures, which makes it easy to use in sow farms different from the reference sow farm and for other measures. WelEc can play an important role in current sow husbandry practices because it provides systematical knowledge on new adaptations in sow husbandry that are important for both farmers and citizens. WelEc combines the interests of farmers, i.e., economics (Bergstra et al., 2013; Bracke et al., 2005), and citizens, i.e., animal welfare (Bergstra et al., 2013). This gives both groups the opportunity to see solutions from their own perspective as well as from the perspective of the other group, which may change their views on sow husbandry. Whether pig farmers want to implement a measure depends on the economic consequences of that measure. The WelEc model gives a clear overview of these economic consequences. Although WelEc also gives an estimation of the effect of measures on animal welfare, it can be questioned whether citizens' interest in animal welfare is fully covered. The animal welfare features in WelEc copied from Welfare Quality® are societally supported (Tuyttens et al., 2010), but they are still being valued technically in the assessment of animal welfare. Such a technical valuation may not improve negative citizens' attitudes toward sow husbandry with respect to animal welfare because citizens do not only look at technical (physical) animal welfare but also at mental animal welfare (Te Velde et al., 2002). The mental animal welfare can partly be measured technically but the judgment of the mental stage of an animal is influenced by value-based views of animal welfare (Fraser, 2008). This might result in lack of citizens' support for selected animal welfare improvement measures.

Consequently, implemented measures to improve animal welfare will not necessarily improve citizens' attitudes. At the same time, measures that are not implemented because of a low effect on animal welfare may have a positive effect on citizens' attitudes. For example, the introduction of analgesia for tail docking will have a small effect on animal welfare and should from that point of view not be implemented. However, the use of analgesia may have a relatively high positive effect on citizens' attitudes. The use of analgesia would then result in a higher citizens' acceptance of tail docking. The effects of animal welfare improvement measures for sow husbandry on citizens' attitudes were not included on our modeling.

5.5 Conclusions

We developed a simulation model (WelEc) to estimate the effects of different measures to improve animal welfare on sow farms on animal welfare and net farm income. The model accounts for the economic interests of farmers and the animal welfare interests of citizens. It is a flexible model that can be customized for different default situations and different animal welfare measures for sow husbandry.

The measures designed to decrease piglet mortality were the most cost-effective. These were the only measures with a positive effect on net farm income but had a relatively low effect on animal welfare. The measure in which gestating sows get the possibility to free range outside and the measure in which the groups of gestating sows are increased and in which the sows receive straw and windows in the outside wall, had the highest effect on animal welfare. These measures had a negative effect on net farm income, but were the most cost-effective compared to the other defined measures with a negative effect on net farm income. All in all, our results show that a positive effect of measures to improve animal welfare in sow husbandry on animal welfare do not necessarily have a negative effect on net farm income. Therefore, before deciding on the implementation of new measures to improve animal welfare on sow farms, it is important to evaluate both the effects of these measures on animal welfare and net farm income. This way, the interests of both citizens and farmers are met.

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Appendix 5.1

Economic input changes per measure to improve animal welfare in sow husbandry

PM1: Camera surveillance farrowing pen

- Piglet mortality is estimated to decrease with 1% with the extra supervision.
- Feed intake sow increases because of piglet mortality decrease. Food intake is 1165 kg/sow/year with piglet mortality of 13% (i.e. 28.33 weaned piglets per year). With 12% piglet mortality, food intake is 1178.57 kg/sow/year.
- The costs for cameras are calculated based on prices charged by a company (cameraindestal.nl, 2014) in the Netherlands. This company charges €500 for the first camera and €200 for each next camera, including installation. The depreciation time of the cameras was estimated at 15 years.
- Extra labor needed to look at the camera footage and to assist piglets in need is estimated at 0.06 hours/sow/year.

PM2: Jute sack provision sow

- Piglet mortality decreases with 0.8% when the sow is provided with two jute sacks (Hoofs, 2012).
- Feed intake sow increases because of piglet mortality decrease. Food intake is 1165 kg/sow/year with piglet mortality of 13% (i.e. 28.33 weaned piglets per year). With 12.2% piglet mortality, food intake is 1175.69 kg/sow/year.
- Cost for one jute sack is €0.90 (expert). One sow needs on average 4.72 (2*2.36) jute sacks per year. A sack holder costs €5 (expert) and is estimated to have a depreciation period of 15 years.
- Extra labor needed to install sack holders and to place jute sacks in the farrowing pens is estimated at 0.036 hours/sow/year.

PM3: Straw provision sow

- Piglet mortality is estimated to decrease with 0.6% with straw provision.
- Feed intake sow increases because of piglet mortality decrease. Feed intake is 1165 kg/sow/year with piglet mortality of 13% (i.e. 28.33 weaned piglets per year). With 12.4% piglet mortality, feed intake is 1173.22 kg/sow/year.
- The costs for the floor element that has to be replaced is estimated at €40 per element with a depreciation period of 15 years.
- Prices for straw were around €35 for 320 kg (marktplaats.nl, 2014).

- Extra labor needed for other tasks (providing straw) was estimated at 0.0066 hours/sow/year.

PM4: Sow habituation

- Piglet mortality is estimated to decrease with 0.6% with sow habituation.
- Feed intake sow increases because of piglet mortality decrease. Feed intake is 1165 kg/sow/year with piglet mortality of 13% (i.e. 28.33 weaned piglets per year). With 12.4% piglet mortality, feed intake is 1173.22 kg/sow/year.
- Extra labor needed to habituate sows is estimated at 0.10 hours/sow/year.

TB1: Tail docking with analgesia

- The costs for piglet analgesia were around €32 per 100 ml (veterinarian). The price of a needleless injection gun was around €200 (schippers.nl, 2014). The depreciation period of such an injection gun was estimated at 15 years.
- Extra labor needed to inject piglets with an analgesia is estimated at 0.09 hours/sow/year.

TB2: Biting material for weaned piglets

- The total costs for enrichment were calculated to be €0.85 sow/year.
- Extra costs for health care were estimated at €1.13 sow/year. These costs increase because tail biting will occur more often. We estimated that 4% of the piglets that are bitten need health care.
- Extra labor needed to install distance holders, renew and replace enrichment was estimated at 0.24 hours/sow/year.
- Extra labor needed to clean pens was estimated at 0.0014 hours/sow/year.

TB3: Straw playing area for weaned piglets

- Floor replacement was estimated to be €0.33 sow/year.
- Price for straw was around €35 for 320 kg (marktplaats.nl, 2014).
- Extra costs for health care were estimated at €0.85 sow/year. These costs increase because tail biting will occur more often. We estimated that 3% of the piglets that are bitten need health care.
- Extra labor needed to clean pens was estimated at 0.090 hours/sow/year.
- Extra labor needed for other tasks (providing straw) was estimated at 0.15 hours/sow/year.

TB4: Chopped straw provision for weaned piglets
- Prices for straw were around €6.00 for 20 kg (stronet.nl, 2014).
- Extra costs for health care were estimated at €0.71 sow/year. These costs increase because tail biting will occur more often. We estimated that 2.5% of the piglets that are bitten need health care.
- Extra labor needed for other tasks (providing straw) was estimated at 0.15 hours/sow/year.

IH1: Free range outside area
- The costs for pen changes was estimated at €7.31 sow/year.
- A decrease of €6.9 sow/year (10%) in health care was expected because of the positive effect of the measure on animal welfare.
- Extra labor needed to clean sow stables was estimated at 0.15 hours/sow/year.

IH2: Straw provision
- Prices for straw were around €35 for 320 kg (marktplaats.nl, 2014).
- A decrease of €4.83 sow/year (7%) in health care was expected because of the positive effect of the measure on animal welfare.
- Extra labor needed to clean sow stables was estimated at 0.075 hours/sow/year.
- Extra labor needed for other tasks (providing straw) was estimated at 0.15 hours/sow/year.

IH3: Straw provision and daylight
- The costs for pen changes was estimated at €2.50 sow/year.
- Prices for straw were around €35 for 320 kg (marktplaats.nl, 2014).
- Because of the window less artificial light is necessary. We estimated a decrease in lighting costs of €0.95 sow/year.
- Because of the windows, heating will change. It is assumed that heating costs on average will be the same because when the sun is shining less heating is necessary and when it is cold and cloudy more heating is necessary.
- A decrease of €4.14 sow/year (6%) in health care was expected because of the positive effect of the measure on animal welfare.
- Extra labor needed to clean sow stables was estimated at 0.075 hours/sow/year.
- Extra labor needed for other tasks (providing straw) was estimated at 0.15 hours/sow/year.

IH4: Straw provision, daylight and increased group size

- The costs for pen changes was estimated at €12.74 sow/year.
- Prices for straw were around €35 for 320 kg (marktplaats.nl, 2014).
- Because of the windows, less artificial light is necessary. We estimated a decrease in lighting costs of €0.95 sow/year.
- Because of the windows, heating will change. It is assumed that heating costs on average will be the same because when the sun is shining less heating is necessary and when it is cold and cloudy more heating is necessary.
- A decrease of €6.21 sow/year (9%) in health care was expected because of the positive effect of the measure on animal welfare.
- It is assumed that less time is needed to clean sow stables because of bigger pens without free access stables. The less labor needed was estimated at 0.23 hours/sow/year.
- Labor needed for other tasks was kept the same as for the reference farm because providing straw takes extra time but the change of system will save time.

Appendix 5.2

Parameter scores per feature of the animal welfare module of WelEc for the default situation and the affected parameter scores relative to the default situation per measure for piglet mortality (PM), tail biting (TB) and indoor housing (IH).

Feature	Default	PM1[a]	PM2	PM3	PM4	TB1	TB2	TB3	TB4
Water supply	400	[b]							
Number of clean drinking spots	350								
Number of sows per drinking spot	1								
Bursitis	0: 60%. 1: 40%								
Absence manure on body sow	0:70%.1:20%.2:10%								
Absence manure on body piglet	0:70%.1:20%.2:10%							0:80%.1:16%. 2:5%	0:80%.1:16%.2:5%
Shoulder sores sow	0:95%.1:4%.2:1%			0:98%.1:1.5%.2:0.5%					
Surface per sow	2.4								
Group size	20								
Lameness sow	0:90%. 1:10%								
Lameness piglet	0:90%. 1:10%						0:95%. 1:5%	0:91%. 1:9%	0:95%. 1:5%
Body wounds sow	0:80%.1:15%.2:5%								
Body wounds piglet	0:98.8%.1:0.5%.2:0.7%						0:80%.1:16%.2:4%	0:86%.1:12%.2:2%	0:88%.1:10%.2:2%
Vulva lesions sow	0:90%,1:8%,2:2%								
Mortality sow	5%								
Mortality piglet	13%	12%	12.2%	12.4%	12.4%				
Tail docking	2: 100%					1:100%	0:100%	0:100%	0:100%
Positive social behavior sow	3.00%				4.00%				
Positive social behavior piglet	8.00%							12.00%	9.00%
Negative social behavior sow	5.00%				4.00%				
Negative social behavior piglet	12.00%						10.00%	8.00%	10.00%
Stereotypies sow	0: 60%. 1: 40%								
Explorative behavior sow	48%		60%	60%					
Explorative behavior piglet	52%						70%	80%	65%
Human-animal relation score sow	0:18%.1:56%.2:26%				0:75%.1:20%.2:5%				
Human-animal relation score piglet	0:5%.1:34%.2:61%						0:10%.1:40%.2:50%	0:16%.1:40%.2:45%	0:20%.1:40%.2:40%
Qualitative Behavioral Assessment (QBA) score sow	-5		-3	-3	-3				
Qualitative Behavioral Assessment (QBA) score piglet	-5						-1	1	-1

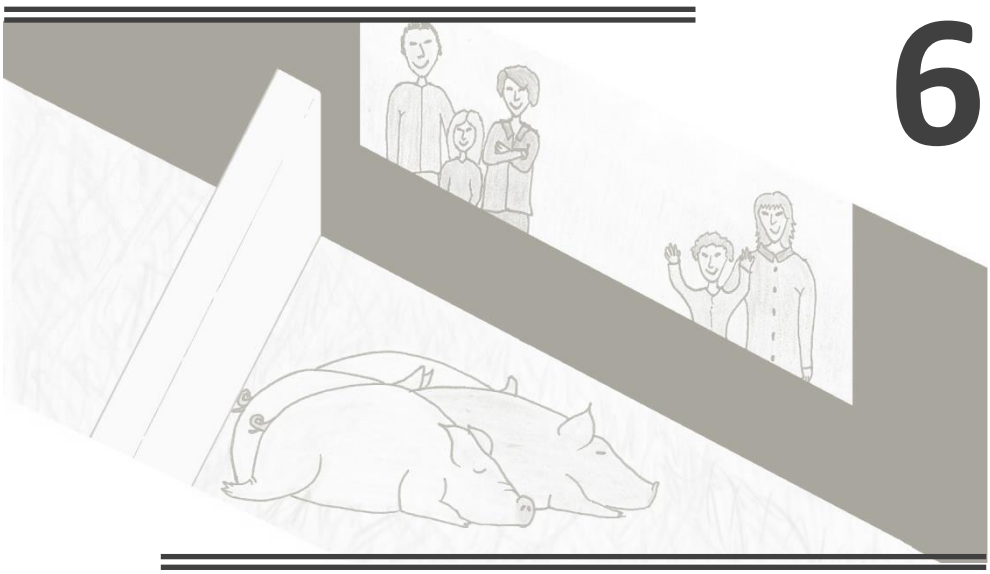
[a] Explanation abbreviations: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets.

[b] When no value is given the same value as in the default situation was assumed.

Feature	Default	HS1[a]	HS2	HS3	HS4
Water supply	400	[b]			40
Number of clean drinking spots	350				38
Number of sows per drinking spot	1				10
Bursitis	0: 60%, 1: 40%	0: 80%, 1: 20%	0: 75%, 1: 25%	0: 75%, 1: 25%	0: 75%, 1: 25%
Absence manure on body sow	0: 70%, 1: 20%, 2: 10%	0: 80%, 1: 13%, 2: 7%	0: 77%, 1: 17%, 2: 6%	0: 77%, 1: 17%, 2: 6%	0: 77%, 1: 17%, 2: 6%
Absence manure on body piglet	0: 70%, 1: 20%, 2: 10%				
Shoulder sores sow	0: 95%, 1: 4%, 2: 1%				
Surface per sow	2.4	4.5			
Group size	20				100
Lameness sow	0:90%, 1:10%	0:95%, 1:5%	0:95%, 1:5%	0:95%, 1:5%	0:95%, 1:5%
Lameness piglet	0:90%, 1:10%				
Body wounds sow	0: 80%, 1: 15%, 2: 5%	0: 90%, 1: 8%, 2: 2%	0: 85%, 1: 12%, 2: 3%	0: 85%, 1: 12%, 2: 3%	0: 90%, 1: 8%, 2: 2%
Body wounds piglet	0: 98.8%, 1: 0.5%, 2: 0.7%				
Vulva lesions sow	0: 90%, 1: 8%, 2: 2%	0: 98%, 1: 1%, 2: 1%	0: 98%, 1: 1%, 2: 1%	0: 98%, 1: 1%, 2: 1%	0: 96%, 1: 2%, 2: 2%
Mortality sow	5%	3%			
Mortality piglet	13%				
Tail docking	2: 100%				
Positive social behavior sow	3.00%	6.00%	4.00%	4.00%	5.00%
Positive social behavior piglet	8.00%				
Negative social behavior sow	5.00%	2.00%	4.00%	4.00%	3.00%
Negative social behavior piglet	12.00%				
Stereotypies sow	0: 60%, 1: 40%	0: 65%, 1: 35%	0: 90%, 1: 10%	0: 90%, 2: 10%	0: 92%, 2: 8%
Explorative behavior sow	48%	80%	70%	70%	80%
Explorative behavior piglet	52%				
Human-animal relation score sow	0: 18%, 1: 56%, 2: 26%	0: 50%, 1: 32%, 2: 18%	0: 40%, 1: 36%, 2: 24%	0: 37%, 1: 38%, 2: 25%	0: 53%, 1: 30%, 2: 17%
Human-animal relation score piglet	0: 5%, 1: 34%, 2: 61%				
Qualitative Behavioral Assessment (QBA) score sow	-5	2	1	1	2
Qualitative Behavioral Assessment (QBA) score piglet	-5				

[a] Explanation abbreviations: IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increase group size.

[b] When no value is given the same value as in the default situation was assumed.



6

Efficiency of measures for sow husbandry based on farm income, animal welfare and citizens' attitudes

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Under review

Abstract

In response to citizens' concerns about animal welfare in sow husbandry, the pig sector introduced measures to improve animal welfare that focus on single rather than multiple dimensions of animal welfare concerns without accounting for their impact on citizens attitudes. These measures failed to improve citizens' attitudes toward sow husbandry. The present study uses a more comprehensive approach by evaluating animal welfare measures in terms of their effects on animal welfare, farm income and citizens' attitudes. Four measures were defined for each of the following issues of sow husbandry: piglet mortality, tail biting and indoor housing of gestating sows. A simulation model was developed to estimate the measure effects and Data Envelopment Analysis was used to compare measures in terms of their effects on both animal welfare, net farm income and citizens' attitudes. The measures for piglet mortality were the only measures with a positive effect on farm income but had a relatively low effect on animal welfare and citizens' attitudes. The most efficient measure was the measure that included straw provision, daylight and increased group sizes for gestating sows. The level of improvement of a measure on animal welfare did not necessarily lead to the same relative improvement of citizens' attitudes or the same relative decrease in farm income. This indicates that a single impact cannot predict the other impacts and that it is essential to use a more comprehensive approach for evaluating animal welfare measures.

Key words

Animal welfare, attitudes, farm income, measures, sow husbandry

6.1 Introduction

In western societies, animal husbandry systems, such as sow husbandry, have been subject to societal animal welfare concerns in the past decades (Ingenbleek et al., 2012; Meuwissen and van der Lans, 2005; Verbeke, 2009; Verbeke and viaene, 2000a). The pig sector responded to these concerns often with measures that focus on measurable physical animal welfare (Beekman et al., 2002) and on a single issue. For example, with regard to the issue 'piglet mortality' the so-called motherless rearing was introduced, a measure that primarily focuses on decreasing piglet mortality (Huysman et al., 1994). Although such measures indeed decreased piglet mortality, they failed to positively influence citizens' attitudes toward sow husbandry as negative attitudes remain (Aarts et al., 2001; Bergstra et al., 2014a; De Greef et al., 2006; Meuwissen and van der Lans, 2005). Hence, it can be noted that the introduction of measures for animal welfare improvement do not always improve citizens' attitudes toward animal treatment in sow husbandry (Beekman et al., 2002).

Attitudes are determined by moral values (Rokeach, 1968-1969), socio-demographic features (Bergstra et al., 2014a; Boogaard et al., 2006; Knight and Barnett, 2008; Knight et al., 2004) and personal interests (Boogaard et al., 2006; Bracke et al., 2005; Te Velde et al., 2002). Moral values are developed through life and are formed by religion, culture, knowledge, education, law and social background (Fraser, 1999). Moral values that play a role in animal husbandry can be divided in three categories: 1) animal conditions should promote good biological functioning, 2) animal suffering should be minimized and contentment promoted and 3) animals should live relatively natural lives (Fraser, 2003). These moral values are weighed against personal factors and interests that are valued with regard to a specific context, e.g., sow husbandry, to form an attitude (Cohen et al., 2009). As interests differ between citizens and pig farmers, both groups will weigh these values differently. Pig farmers' interest in animal production (Bock et al., 2007; Van Huik and Bock, 2007) and economics (Bergstra et al., 2014b; Bracke et al., 2005; De Greef and Casabianca, 2009; Te Velde et al., 2002) will make them focus on the results and the economic consequences of a measure. The lower interest of citizens in economics and the higher interest in animal welfare (both physical and mental) and human health (Bergstra et al., 2014b; Te Velde et al., 2002) will make citizens focus on the side effects of measures. For example, with regard to motherless rearing, pig farmers look at the decrease of piglet mortality while citizens mainly consider the effect of this measure on the 'natural lives' of the piglets now they are being raised without a mother. Another example is the use of antibiotics in pigs. Pig farmers see the benefits of using antibiotics because it has a positive

effect on animal production (Cromwell, 2002) but citizens fear the effect of residuals in meat on human health (Frederiksen et al., 2010; Huber-Eicher and Spring, 2008; Ngapo et al., 2003). That citizens and pig farmers weigh their moral and personal values differently results in different attitudes toward sow husbandry between these groups (Bergstra et al., 2014c; Lassen et al., 2006; Te Velde et al., 2002; Tuyttens et al., 2010; Vanhonacker et al., 2008).

The failure of the already introduced measures for animal welfare improvement to improve citizens' attitudes and the importance of economic indicators for pig farmers in deciding on implementation of these measures, implies that development of new measures for sow husbandry has to be based on a more comprehensive approach (Bennett, 1997; McGlone, 2001; Mellor and Stafford, 2001). With this approach, the effects of measures on animal welfare, farm income and citizens' attitudes have to be considered. Several previous studies on animal welfare improvement in animal husbandry systems accounted only for animal welfare and farm income (Bergstra et al., 2014c; Bornett et al., 2002 ; Bruijnis et al., 2013; Stott et al., 2012; Vosough Ahmadi et al., 2011). Ingenbleek et al. (2012) developed a decision tree to compare different policy instruments for livestock industry in their effect on improving animal welfare levels reflecting societal concerns. Although these policy instruments were developed based on societal concerns, they were compared only in their effects on animal welfare (Ingenbleek et al., 2012). Other studies focused on animal welfare and attitudes through measures of consumers' willingness to pay for animal welfare (Bennett et al., 2012; Bennett, 1997; Glass et al., 2005; Kehlbacher et al., 2012; Lagerkvist and Hess, 2011; Nocella et al., 2010). Den Ouden et al. (1997) calculated the financial costs that accompany pig welfare concerns but did not include the technical animal welfare effects. Current literature lacks a more comprehensive approach in which animal welfare, farm income and citizens' attitudes are integrated. Gocsik et al. (2013) are the first who describe an approach that includes animal welfare, farm income and attitudes. However, this is a conceptual approach that focuses on farmers' attitudes.

In the light of the foregoing discussion, the objectives of the present study were 1) to determine the effects of measures for the improvement of animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes, and 2) to compare these measures in terms of these effects. For the first objective a simulation model was developed to calculate the effects of measures. For the second objective the benchmarking technique Data Envelopment Analysis was used to compare the performance of the different measures.

6.2 Material and methods

To estimate the effects of different measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes, we focus on sow husbandry measures and build further on the simulation model described in Bergstra et al. (2014c). Bergstra et al. (2014c) describes the animal-welfare-economics (WelEc) model which calculates the effects of different measures for sow husbandry on animal welfare and farm income. We have expanded this model by including the effects of sow husbandry measures on citizens' attitudes. The present study will first explain the measures and a reference farm for measure implementation. Then the model we used will be presented, parameterization of the model will be described and, finally, the use of Data Envelopment Analysis in comparing measures will be explained.

Measures and reference sow farm

The measures that we focus on were related to issues of sow husbandry, i.e., piglet mortality, tail biting and indoor housing of gestating sows. Tail biting and indoor housing are important in the attitudes of Dutch citizens toward sow husbandry (Bergstra et al., 2014b) and piglet mortality received a lot of media attention in the Netherlands (Stichting Varkens in Nood, 2010; Wakker dier, 2010). For each of these issues, four measures were defined. To be able to estimate the effects of measures to improve animal welfare in sow husbandry, a reference sow farm representative for the Netherlands was defined. The characteristics of this farm are shown in Table 6.1.

How the reference farm is dealing with the aforementioned issues will be described next. Gestating sows are housed indoor in pens with free access stalls. The pen floor consists of 70% solid concrete and 30% slatted concrete. Nine hours per day light intensity in the stables is arranged with artificial light as natural light has no access inside. Twice daily the gestating sows are fed in their own feeding trough. The gestating sows are confined in farrowing pens five days before farrowing and will stay confined until piglets are weaned. When piglets are born they are checked twice daily during sow feeding. Assistance is offered to the piglets when needed. When piglets are 2 to 5 days old, their tails are docked without anesthesia. When weaned, piglets from several litters will be housed in groups of 40 individuals in pens of 16 m^2. The floor of these pens consists of 40% solid concrete and 60% slatted concrete. Each pen contains two chains for enrichment. More details on the reference sow farm can be found in Bergstra et al. (2014c).

Table 6.1 Characteristics of the reference sow farm

Characteristic	
Farm size (no. of sows)	400
Number of litters per sow per year	2.36
Live born piglets per litter	13.8
Piglet mortality	13%
Sows replacement rate	43%
Weaning age	26 days
Piglet age when sold	10 weeks
Number of sows per group	20
Number of weaned piglets per group	40
Number of gestation crates	320
Number of farrowing pens	120
Number of weaned piglet pens	50
Surface of sow pen per group	42 m2
Surface of gestation crate	1.2 m2
Surface of weaned piglet pen	16 m2

Source: Bergstra (2014c)

The defined measures were designed in such a way that they could be implemented in the reference sow farm. Below, these measures will be briefly described. An extensive description of these measures can be found in Bergstra et al. (2014c).

The defined measures to reduce piglet mortality (PM):

- PM1: Camera surveillance farrowing pen

Surveillance cameras will be installed in the farrowing pens to monitor the sow and piglets during the first 48 after parturition. Monitoring will be done every hour (from 7.30 AM until 9.30 PM). When necessary the farmer will go inside the farrowing pens to assist piglets in need. One camera is able to monitor two farrowing pens. Every week 10 cameras will be in use to record the sows that farrow that week. To watch the camera footage there has to be invested in a monitor for in the stables, assuming that the farmer of the reference sow farm already owns a monitor inside the house and a smartphone to display footage on.

- PM2: Jute sack provision sow

Two jute sacks will be provided to the sow as soon as she is confined in a farrowing pen. A sack holder will keep the jute sacks in place close to the sow's head. Sows will have access to the jute sacks throughout the farrowing period.

- PM3: Straw provision sow

Half a day before farrowing, sows in farrowing pens will receive 300 grams of straw in their trough. The slatted floor element underneath the trough will be replaced by a solid floor element to prevent straw from falling in the manure drain.

- PM4: Sow habituation

New reproduction sows will be habituated to get used to human handling. When these sows arrive at the farm, the farmer will spend two times per day two minutes with the sow for a period of one week. During this period the farmer will touch the sow gently at different body parts and talk to her with a calm voice. As a reward the sow will randomly receive pellets in a trough or on the floor. Positive interactions between the farmer and sows have to be maintained after the habituation period, for example, by touching sows every now en then when walking through the pens.

The defined measures to keep tail biting (TB) low:

- TB1: Tail docking with analgesia

At least 30 minutes before tails are being docked, a nonsteroidal anti-inflammatory drug will be injected intradermal. This will be done with needleless injections. In the Netherlands, pig farmers are allowed to administer analgesia after prescription of a veterinarian.

- TB2: Biting material for weaned piglets

The tails of piglets will no longer be docked. Instead, environmental enrichment will be provided to weaned piglets. Every day each pen receives randomly two of the following enrichment objects: chain, chain with wood, bobbin with rope, chain with rubber and plastic ball. The enrichment objects will be connected to distance holders which are attached to the pen wall at a height of 100 cm. The distance holders ensure that the enrichment objects are placed inside the pen 20 cm from the wall.

- TB3: Straw playing area for weaned piglets

The tails of piglets will no longer be docked. Instead, each weaned piglet pen will receive a straw playing area of 6 m^2 on the solid concrete floor. A bar will be placed on the floor to separate the playing area from the rest of the pen. When pens are cleaned, every 6 weeks, straw in the straw playing area will be replaced by 5 kg fresh straw. Straw will be supplemented with 10 gr per animal daily.

- TB4: Chopped straw provision for weaned piglets

The tails of piglets will no longer be docked. Instead, weaned piglets will receive 10 gr chopped straw per piglet twice daily.

Defined measures to improve indoor housing (IH) of gestating sows:

- IH1: Free range outside area

Each gestating sow pen will receive an opening of 3 meters wide and 1.5 meter high in the outside wall that will give sows outside access. Rubber flap doors will close of the passage to keep indoor temperatures at a respectable level. The outside enclosure will have a surface of 42 m^2 and will be fenced with an iron fence. The outside floor will be excavated and will receive white sand as bedding.

- IH2: Straw provision

Gestating sows will receive 100 gr straw per sow daily.

- IH3: Straw provision and daylight

Gestating sows will receive 100 gr straw per sow daily and each pen will receive an insulated window of 2m by 1m.

- IH4: Straw provision, daylight and increased group size

Groups of gestating sows will be increased from 20 to 100 individuals. To house the sows, five pens will be combined into one and the free access stalls will be removed. The separate feeding troughs will be replaced by an electronic feeding system with two feeding places in each pen. The one-week system will change into a five-week system, which means that all farrowing pens will be occupied at the same time. Each gestating sow will receive 100 gr straw daily and each pen will receive an insulated glass window of 4m by 1m in the outside wall.

Simulation model

To calculate the effects of the different defined measures to improve animal welfare, we developed a simulation model. This model is an extension of the WelEc model. Because the WelEc model is explained in Bergstra et al. (2014c) we will only describe it briefly here. The WelEc model was developed to calculate the effects of measures for sow husbandry on animal welfare and farm income. It consists of an economic module and an animal welfare module. The economic module calculates the net farm income (€/year): $\mathrm{NFI} = \mathrm{TRE} - \mathrm{TCO}$, where TRE refers to total returns and TCO refers to total costs. The animal welfare module calculates the total animal welfare score for a farm: $\mathrm{TWS} = \sum_{i=1}^{27}(\mathrm{AWS}_i)$, where AWS_i refers to animal welfare score for animal welfare feature i of the 27 animal welfare features. These twenty-seven features were assigned to the animal welfare module based on features used in Welfare Quality® (Blokhuis, 2008b). Each animal welfare feature received a score between 1 (worst for animal welfare) and 100 (best for animal welfare), which made the maximum possible TWS 2,700.

The model used in the present study consisted of the previously developed modules of the WelEc model extended with an attitude module. The attitude module was based on work of Bergstra et al. (2014a) who studied citizens' attitudes toward sow husbandry with respect to different entities, i.e., animals, humans and the environment. To aspects related to these entities, e.g., animal mortality, litter size, income of the farmer, public health risks and environmental waste, respondents to a previously held questionnaire assigned additional care levels. These additional care levels indicated the extra attention respondents considered necessary for the aspects in current sow husbandry and are representative for negative attitudes toward this practice. In the attitude module of our simulation model, 25 aspects were included for which negative attitude scores were indicated on a scale of 1 (no negative attitude) to 5 (maximum negative attitude). A total attitude score was calculated by: $\mathrm{TAS} = \mathrm{TAS}_{max} - \mathrm{NAS}$, where TAS_{max} was the maximum possible total attitude score and NAS was the total negative attitude score. The maximum possible total attitude score was in this case 125; 25 aspects times the maximum possible score of 5 (negative attitude scores reversed). The total negative attitude score was calculated by: $\mathrm{NAS} = \sum_{i=1}^{25} (\Delta\mathrm{NA}_i * \mathrm{IS} + \mathrm{NA}_{r,i})$, where $\Delta\mathrm{NA}$ is the difference in negative attitude score for aspect i of the 25 aspects between the reference farm and after measure implementation, IS is an importance score assigned to each measure in relation to the relevant issue (i.e., piglet mortality, tail biting and indoor housing) and NA_r is the negative attitude level for the reference farm r for aspect i. The importance scores were based on results from Bergstra et al. (2014a). Bergstra et al. (2014a) showed percentages of Dutch citizens that found certain issues of sow husbandry unacceptable. For the issue 'piglet mortality', 21% of citizens indicated this to be unacceptable, which resulted in an importance score of 0.21 for piglet mortality. The issue 'tail biting' was not addressed in the study of Bergstra et al. (2014a). However, respectively 60% and 83% of citizens indicated to find tail docking and interventions without sedation unacceptable. Both issues are strongly related to tail biting and, therefore, the average of these percentages respondents (0.71) was used for the importance score for tail biting. For the issue 'indoor housing' 69% of citizens indicated to find this unacceptable, resulting in an importance score of 0.69 for indoor housing.

Parameterization

The calculations in the economic module were based on several farm inputs, e.g., technical numbers such as farm size and piglet mortality, investments and animal prices. Default values were assigned to the reference farm, based on the Dutch animal husbandry

handbook (KWIN-Veehouderij, 2013/2014), a database with official yearly numbers of the pig sector (Agrovision b.v., 2012) and input from a farmer with a sow farm comparable to the reference farm. To the few inputs that were not valued based on available information, a value was assigned based on our own expertise. For each measure it was determined, based on knowledge of experts in economics and animal production systems, which inputs would change after measure implementation. These changes with regard to the default situation were processed in the economic module to calculate the net farm income after implementation of each measure. An extensive description of inputs and calculations with regard to the economic module can be found in Bergstra et al. (2014c). In the present study we included a variation in inputs because the effects on farm income of the measures are uncertain. This variation was based on an input change of 5%. The inputs and variation can be found in Appendix 6.1.

For the animal welfare module, animal welfare features were selected from Welfare Quality®. In Welfare Quality®, a model with different animal welfare features was developed for the assessment of animal welfare of different types of farm animals (Blokhuis, 2008b; Botreau et al., 2007). As Welfare Quality® does not focus on piglet welfare, animal welfare features for piglets were added to the animal module. To each feature an animal welfare score was assigned for the default situation, based on average scores for a sow farm in the Netherlands (Vermeer et al., 2012). For each measure it was decided which features would change after measure implementation with regard to the default situation. For these features the animal welfare scores were adjusted. An extensive description of the animal welfare scores can be found in Bergstra et al. (2014c). In our model we included a variation for animal welfare scores because it is uncertain what the animal welfare effects are. The animal welfare scores and the variation can be found in Appendix 6.2.

For the attitude module, the results on additional care levels that citizens' assigned to aspects of sow husbandry from the study of Bergstra et al. (2014a) were used. The average of these additional care levels were used as negative attitudes scores for the default situation in the present study. The aspects toward which attitudes were expected to change after implementation of one of the defined measures were selected. To each of these aspects the change in negative attitude with regard to the default situation and the variation was indicated based on our expertise (Appendix 6.3).

Comparing measures: Data Envelopment Analysis

To compare the overall effect of measures for sow husbandry on animal welfare, farm income and attitudes toward sow husbandry, Data Envelopment Analysis (DEA) was used. DEA is a non-parametric linear programming technique to assess the relative productive efficiency of a group of producers, such as pig farmers, referred to as decision making units (DMU's) (Huijps et al., 2010; Martić et al., 2009). For each producer a benchmark is constructed based on a set of common inputs that generates a set of common outputs (Huijps et al., 2010; Martić et al., 2009). DEA can also be used to compare measures with multiple inputs and multiple outputs (see for example (Huijps et al., 2010)) which is the case in our study.

One input (total costs) and three outputs, i.e., total returns, total animal welfare scores and total attitude scores, were distinguished in the DEA model. The input and outputs were obtained from the farm income, animal welfare and attitude modules of our simulation model. An output oriented DEA was used, which implies that the DEA model maximizes output given the level of input used. The efficiency frontier was calculated under variable returns to scale, which takes into account that when the input changes the outputs can increase more or less than proportional. The radial distance of a DMU from the efficiency frontier indicates the technical efficiency of this DMU. Technical efficiency F for DMU o was calculated as:

$$\underset{F,\lambda^1,\ldots,\lambda^K}{Max\ F}$$

s.t.

$$x^o \geq \sum_{k=1}^{K} \lambda^k x^k$$
$$Fy^o \leq \sum_{k=1}^{K} \lambda^k y^k$$
$$\sum_{k=1}^{K} \lambda^k = 1$$

where K indicates the number of DMU's. DEA was carried out with 1) impact on all three outputs, 2) impact on animal welfare and attitudes and 3) impact on only attitudes.

Because the input and outputs for DEA were stochastic variables, for each measure DEA was run a 1,000 times with random values from a uniform distribution for the input and each output. The minimum and maximum values for the uniform distribution were obtained from our simulation model. From the 1,000 DEA iterations, the averages and 95% confidence intervals were calculated. DEA was run in R version 3.0.0 (2013) and the averages and confidence intervals were calculated with IBM SPSS Statistics 20 (IBM Corporation, New York, United States).

6.3 Results

Effects of measures on animal welfare, farm income and citizens' attitudes separately

The effects of different measures for sow husbandry on farm income, animal welfare and citizens' attitudes toward sow husbandry were computed. The means and variation of these effects for the default situation and after implementation of the different measure are shown in Table 6.2.

Table 6.2 Farm income (€/year), animal welfare and attitude outputs of the simulation model; the mean (μ) and variation (Var) for net farm income (NFI), total costs (TCO), total returns (TRE), total animal welfare score (TWS) and total attitude score (TAS) for the default situation and the different measures.

Measure[a]	μ NFI	Var NFI	μ TCO (x100)	Var TCO (x100)	μ TRE (x100)	Var TRE (x100)	μ TWS[b]	Var TWS	μ TAS[c]	Var TAS
Default	-38177	0	5514	0	5132	0	1555	0	32.7	0
PM1	-36475	1545	5497	15.4	5188	280.7	1556	0.2	33.6	0.5
PM2	-37850	1562	5511	15.6	5177	305.7	1580	11.4	33.1	0.2
PM3	-36762	1498	5500	15.0	5166	306.0	1583	12.9	33.6	0.5
PM4	-37322	1493	5505	14.9	5166	311.6	1628	13.7	33.0	0.1
TB1	-39607	74	5528	0.7	5132	0.0	1580	0.0	35.9	1.8
TB2	-41218	151	5544	1.5	5132	0.0	1692	24.9	38.3	2.3
TB3	-41895	185	5551	1.9	5132	0.0	1739	36.0	39.6	3.2
TB4	-39959	88	5532	0.9	5132	0.0	1716	35.8	39.0	3.0
IH1	-39712	353	5529	3.5	5132	0.0	1770	57.9	41.8	6.4
IH2	-39916	279	5531	2.8	5132	0.0	1709	61.4	34.4	2.0
IH3	-40814	334	5540	3.3	5132	0.0	1706	58.4	35.1	2.3
IH4	-39950	578	5532	5.8	5132	0.0	1809	65.8	39.6	3.9

[a] Measure abbreviations: PM: piglet mortality, TB: tail biting, IH: indoor housing gestating sows, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.

[b] TWS: animal welfare score with a maximal possible score of 2700 (27 animal welfare features times a maximum score of 100).

[c] TAS: attitude score with a maximal possible score of 125 (25 attitude features times a maximum score 5).

For the default situation, fixed numbers without variation were calculated. The measures for piglet mortality were the only measures with a positive effect on net farm income, total costs and total returns. The effects of the measures for piglet mortality on animal welfare

and attitudes was low compared to the other measures, except for tail docking with analgesia (TB1). The latter had a slightly higher score for attitude but an equal animal welfare score compared to the measures for piglet mortality. A straw playing area for weaned piglets (TB3) had the highest negative effect on net farm income with the highest total costs compared to the other measures. The animal welfare and attitude score of TB3 was relatively high. The highest animal welfare and attitude scores were given to measures for indoor housing of gestating sows (IH). Free range outside housing (IH1) received the highest attitude score compared to the other measures and the second highest animal welfare score. The measure 'straw provision, daylight and increased group size' (IH4) received the highest animal welfare score compared to the other measures and the second

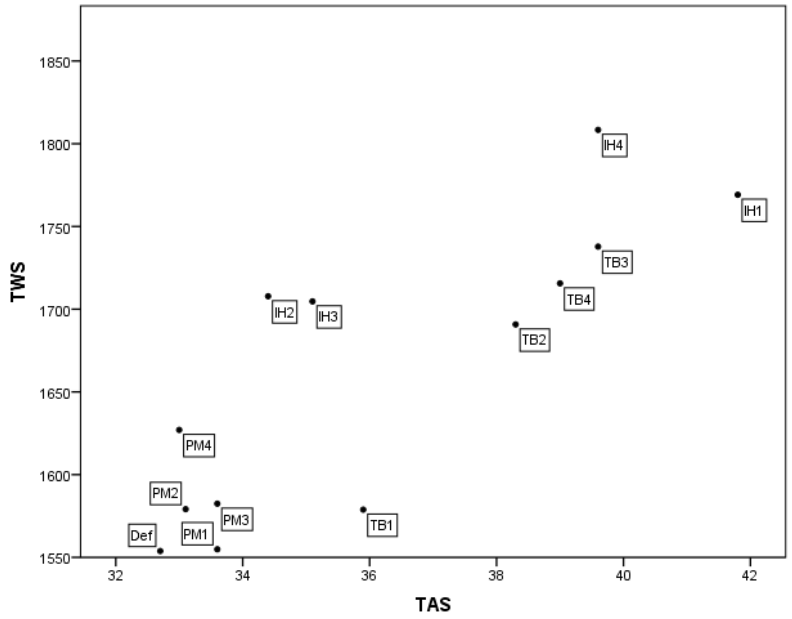

Figure 6.1 The effects of measures for sow husbandry on animal welfare and attitudes; total animal welfare scores (TWS) and total attitude scores (TAS) of the default situation (Def) and the different measures for sow husbandry.
TWS: total animal welfare score with a maximal possible score of 2700 (27 animal welfare features times a maximum score of 100).
TAS: attitude score with a maximal possible score of 125 (25 attitude features times a maximum score of 5).
Explanation abbreviations of measures: PM: piglet mortality, TB: tail biting, IH: indoor housing gestating sows, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.

highest attitude score. The total effects on animal welfare and attitude of the default situation and the different measures are visualized in Figure 6.1. The effects on animal welfare were comparable for biting material for weaned piglets (TB2), chopped straw provision for weaned piglets (TB4), straw provision (IH2) and straw provision and daylight (IH3), but the effects on attitudes were different, especially between the tail biting measures and the indoor housing measures (Table 6.2 and Figure 6.1).

Combined effects of measures

To compare the combined effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and attitudes toward sow husbandry, technical efficiencies were calculated with DEA. The input 'total costs' and outputs 'animal welfare scores' and 'attitude scores' for DEA were derived from our simulation model. Mean technical efficiencies and the 95% confidence intervals of the 1,000 DEA iterations per measure are shown in Table 6.3.

Table 6.3 Mean (μ) technical efficiencies (TE) and 95% confidence intervals (CI) resulting from 1,000 data envelopment analysis iterations under variable returns to scale with impacts on farm income (FI), animal welfare (AW) and/or attitudes toward sow husbandry (AT) for the default situation and measures for sow husbandry.

		Impact on..	Default	PM1*	PM2	PM3	PM4	TB1	TB2	TB3	TB4	IH1	IH2	IH3	IH4
TE	μ	FI, AW, AT	.966	.993	.979	.990	.992	.975	.987	.994	.992	.999	.986	.986	1.000
	μ	AW, AT	.908	.987	.957	.985	.987	.884	.944	.973	.965	.996	.946	.940	1.000
	μ	AT	.824	.981	.903	.969	.940	.820	.868	.909	.897	.983	.756	.770	.993
CI	Lower bound	FI, AW, AT	.966	.992	.978	.989	.991	.975	.987	.993	.991	.999	.986	.985	1.000
	Upper bound		.967	.994	.980	.991	.993	.976	.988	.994	.992	.999	.986	.986	1.000
	Lower bound	AW, AT	.907	.986	.954	.983	.989	.882	.942	.972	.963	.995	.945	.939	1.000
	Upper bound		.909	.989	.957	.986	.990	.886	.945	.974	.966	.997	.947	.941	1.000
	Lower bound	AT	.820	.978	.897	.966	.945	.815	.863	.904	.892	.980	.751	.765	.991
	Upper bound		.828	.983	.903	.972	.948	.825	.873	.913	.902	.985	.762	.776	.995

* Measure abbreviations: PM: piglet mortality, TB: tail biting, IH: indoor housing gestating sows, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.

The default situation was on average inefficient for the three different impacts used in DEA. When DEA used the impact on farm income, animal welfare and attitudes, the default situation was most inefficient compared to situations in which one of the measures was implemented. The measure 'straw provision, window and increased group size' (IH4) was

the only measure that was fully efficient when DEA used the impact on farm income, animal welfare and attitudes and the impact on animal welfare and attitudes. When DEA used the impact on only attitudes, none of the measures was fully efficient but measure IH4 was the least inefficient compared to the other measures and the default situation. The free range outside area (IH1) was, after measure IH4, the least efficient for all impacts. The technical efficiency scores were generally lower when DEA used the impact on only attitudes compared to the other impacts. When this impact was used, the lower and upper bound of the confidence intervals were further apart compared to the other impacts. The variation in technical efficiency was also highest when DEA used the impact on only attitudes (Figure 6.2a) compared to the other impacts (Figure 6.2b and 6.2c). The variation in technical efficiencies were lowest when DEA used the impact on both, farm income, animal welfare and attitudes (Figure 6.2a) compared to the other impacts (Figure 6.2b and 2c). For all three impacts that DEA used, measure IH4 showed the least variation and was first-order stochastically dominant over all other measures and the default situation (Figure 6.2). When DEA used the impact on both, farm income, animal welfare and attitudes and on farm income and attitudes (Figure 6.2a and 6.2b), measure IH1 was first-order stochastically dominant over all other measures, except measure IH4, and the default situation but when DEA used the impact on attitude (Figure 6.2c) measure IH1 was only stochastically dominant over three other measures and the default situation. When DEA used the impact on farm income, animal welfare and attitudes, all measures were first- or second-order stochastically dominant over the default situation. When DEA used the impact on animal welfare and attitudes, the default situation was second-order stochastically dominant over measure TB1. When DEA used the impact on attitude, the default situation was first-order stochastically dominant over measure IH2 and second-order dominant over measure TB1.

6.4 Discussion

The objectives of the present study were 1) to determine the effects of measures for the improvement of animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes, and 2) to compare these measures with regard to these effects. The effects of the measures were computed using a simulation model based on WelEc (Bergstra et al., 2014c). Bergstra et al. (2014c) showed that their model can be used to compare measures for sow husbandry in their effects on farm income and animal welfare.

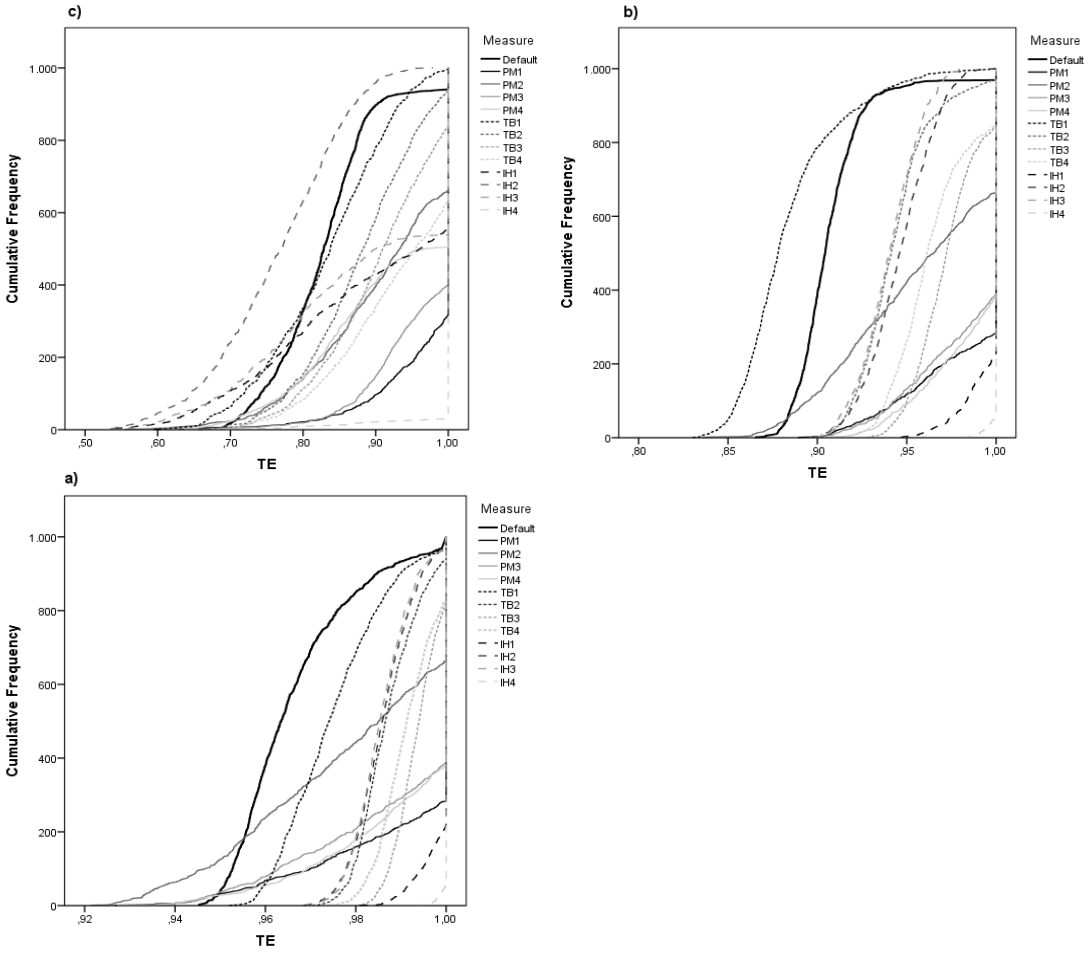

Figure 6.2 The variation in technical efficiency (TE) resulting from 1,000 iterations in data envelopment analysis under variable returns to scale with impact on a) farm income, animal welfare and attitudes, b) animal welfare and attitudes, and c) attitudes for the default situation and measures for sow husbandry.
Measure abbreviations: PM: piglet mortality, TB: tail biting, IH: indoor housing gestating sows, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.

Therewith, the economic interests of famers (Bergstra et al., 2014b; Te Velde et al., 2002) and the animal welfare interests of citizens' (Bergstra et al., 2014b) are being addressed. However, WelEc does not include the actual effects of sow husbandry measures on citizens' attitudes toward sow husbandry. Therefore, we extended WelEc by adding an attitude module to the animal welfare and economic module. In the attitude module, attitude aspects described in Bergstra et al. (2014a) were included. Bergstra et al. (2014a) showed that the wide range of aspects related to animals, humans and the environment that they described, such as mortality and pain in animals, income for animal keepers, public health risks and environmental waste, are important in attitudes toward sow husbandry of Dutch citizens. This means that all these aspects should be considered in the effects of measures to improve animal welfare in sow husbandry on citizens' attitudes. We focused on this wide range of aspects and included the aspects that were considered relevant, based on our expertise, for the defined measures in our model. For the measures, effects on animal welfare, farm income and citizens' attitudes were simulated on the basis of a default situation, which was a reference sow farm representative for the Netherlands. For each of these measures, total efficiencies were calculated based on their effects on animal welfare, farm income and citizens' attitudes with data envelopment analysis (DEA). We decided to use DEA because this method allowed for integrating various impacts into one overall score, i.e., efficiency.
In this study we focused on sow husbandry in the Netherlands. As the Netherlands is an important exporting country with regard to pig production, mainly for Germany, Italy and United Kingdom (LTO Nederland, 2005-2006), sow husbandry in the Netherlands is also important for citizens and consumers in other countries. Furthermore, discussion about intensification of animal husbandry systems in relation to animal welfare is a subject of discussion throughout the European Union (Van der Meulen et al., 2011) and most of the Europeans believe that animal welfare in these systems is between moderate and very bad (Verbeke, 2009). The model presented in the present study can also be useful for other countries because inputs can be customized for other countries.

Results of our study showed that the effects of measures for sow husbandry on farm income, animal welfare and attitudes differed. This means that, for example, the level of improvement of animal welfare does not necessarily lead to the same level of improvement of citizens' attitudes and thus, that one effect cannot predict the other effects. Previous studies on economic consequences of the welfare improvements of different farm animals also concluded that the improvement of animal welfare did not correlate with economic effects (Bruijnis et al., 2013; Cain and Guy, 2006; Seddon et al., 2013; Stott et al., 2012;

Vosough Ahmadi et al., 2011). But in studies that included citizens' or consumers' attitudes by asking them their willingness to pay for animal welfare improvement it seemed that there was a positive correlation. People were willing to pay more for products of animals that had a higher welfare (Bennett et al., 2012; Bennett, 1997; Glass et al., 2005; Kehlbacher et al., 2012; Lagerkvist and Hess, 2011; Nocella et al., 2010). It seems that this willingness to pay does not relate to citizens' attitudes toward measures to improve animal welfare that are implemented in sow husbandry. This is probably because citizens weigh their moral values, personal values and interests with regard to animal welfare different than pig farmers (Cohen et al., 2009) and pig farmers decide to a great extent which measures are implemented. Conventional pig farmers focus on animal production and are primarily interested in physical animal health (Bock et al., 2007; Van Huik and Bock, 2007) and the economic consequences of a measure (Bracke et al., 2005; De Greef and Casabianca, 2009; Te Velde et al., 2002). When a measure improves physical animal health, it improves animal production and consequently, it has a positive effect on farm income. If these improvements are viable for pig farmers, they will support that measure. Citizens focus on both physical and mental animal welfare (Te Velde et al., 2002) and consider the side-effects of measures on animals. This means that a measure with a positive effect on physical animal welfare will not be supported by citizens when they believe, based on their moral values, that the effect on mental animal welfare (e.g., natural behavior) is negative. Furthermore, there is discussion about whether this willingness to pay refers to only animal welfare or that animal welfare is only used as indicator for other aspects (Bennett et al., 2012; Hudson, 2010; Svedalis and Harvey, 2006). Aspects like food safety, healthiness, type of product and quantity are taken into account in quantifying willingness to pay (Harper and Henson, 2001; Svedalis and Harvey, 2006). Similar aspects related to human health and the environment are considered when citizens form attitudes toward sow husbandry (Bergstra et al., 2014a; Meuwissen and van der Lans, 2005; Verbeke and Viaene, 2000b).

That a positive effect of measures to improve animal welfare in sow husbandry on animal welfare does not necessarily improve citizens' attitudes toward sow husbandry to the same extent makes it essential to look at effects of these measures on animal welfare and citizens' attitudes separately. The present study is the first that makes this separation and uses a more comprehensive approach by including animal welfare, farm income and citizens' attitudes. By using a more comprehensive approach, different effects of measures to improve animal welfare in sow husbandry were integrated into a single metric (Van den Besselaar and Heimeriks, 2001). In the development of measures for sow husbandry, the

sector only focuses on the effects on animal welfare and farm income. Because the effects on citizens' attitudes are not included, their approach is doomed to fail.

That the approach used by the pig sector gives a different idea about the efficiency of a measure than the more comprehensive approach we used is shown in the present study. For example, the defined measures for piglet mortality were the only measures with a positive effect on both animal welfare, net farm income and attitudes. Based on that information it looks like those measures are more efficient than the other defined measures. However, with the approach used in this study, it became clear that the measure 'straw provision, daylight and increased group size for gestating sows' was overall the most efficient measure and that the measures for piglet mortality were overall inefficient. These differences in efficiency were the cause of higher effects of the measure 'straw provision, daylight and increased group size for gestating sows' on animal welfare and citizens' attitudes compared to the measures for piglet mortality. The higher effect on citizens' attitudes can be explained by that citizens find it important that animals have daylight and space (Boogaard et al., 2011b) which was part of this measures' focus. Furthermore, Bergstra et al. (2013) showed that Dutch citizens did not have an opinion about piglet mortality which might explain the low effect of measures for piglet mortality on citizens' attitudes. The higher effect on animal welfare of the measure 'straw provision, daylight and increased group size for gestating sows' can be explained by more features in the animal welfare module being affected by this measure compared to the measures for piglet mortality (Appendix 6.2).

When DEA used the impact on only attitudes, the efficiency scores were lower and the confidence intervals of these scores were larger for all measures compared to when DEA used the impact on animal welfare and attitudes or on animal welfare, attitudes and farm income. This indicates that there is a higher uncertainty in the effects on attitudes. This uncertainty is reflected in the relatively high variation in the effects of measures to improve animal welfare in sow husbandry on attitudes compared to the effects on farm income and animal welfare. The attitude effects are uncertain because citizens' attitudes are influenced by several factors, such as socio-demographic features (Bergstra et al., 2013; Boogaard et al., 2006; Knight and Barnett, 2008; Knight et al., 2004), personal interests (Boogaard et al., 2006; Bracke et al., 2005; Te Velde et al., 2002) and the media (Boogaard et al., 2011a; Boogaard et al., 2006; Knight and Barnett, 2008). These factors define how citizens weigh their moral values against other personal values in forming an attitude (Cohen et al., 2009) toward, in this case, sow husbandry. Attitudes change over time because of changing technologies, new ideas about animal husbandry and higher citizens' interests in food production methods (Chrispeels and Mandoli, 2003). Because of these changes and the

uncertainty of what will be presented in the media, it is difficult to predict the extent to which attitudes will change. The change in attitudes by introducing measures to improve animal welfare in sow husbandry will be influenced by information about these measures by the sector. When citizens are not informed about these measures they will be unaware of the changes that are made and they will not change their attitudes toward sow husbandry. There are several methods to provide this information, such as presenting it as news items or through social media on the internet (Rutseart et al., 2014). Which methods are best to use is a discussion on its own and is beyond the scope of the present paper.

The effects of measures to improve animal welfare in sow husbandry on citizens' attitudes were low. Although these effects were low, it may still be interesting to implement the most efficient measures because they improve citizens' attitudes. An improvement of citizens' attitudes, even if the improvement small, may give the pig sector a more positive image. A reason for the small effect of these measures on citizens' attitudes can be that the defined measures are developed for implementation in an existing sow farm. Making changes in an existing farm may not have the desired effect on animal welfare due to citizens. Rebuilding a farm to improve animal welfare may have a stronger effect on citizens' attitudes but is associated with higher costs. Several new housing designs are developed that possibly can change negative citizens' attitudes in positive attitudes toward the particular animal husbandry system, such as 'Vair varkenshuis' (Vair) and 'Comfort Class' for pigs (De Greef et al., 2011), 'Rondeel' for laying hens (Van Niekerk and Reuvekamp, 2011) and 'Koeientuin' for cows (Galama et al., 2009). These designs are developed to replace existing farms and involve high investment costs which results in higher production costs (Galama et al., 2009; Van Niekerk and Reuvekamp, 2011). These higher costs may result in an overall inefficiency when the effects on animal welfare, farm income and attitudes are integrated.
In order to improve the citizens' attitudes toward sow husbandry it is necessary to find measures that are overall efficient in their effects on animal welfare, farm income and citizens' attitudes. This paper allows for identifying such measures and based on the findings, policy makers and farmers can take further steps. For example, taxes can be lowered or subsidies can be provided for efficient measures, to stimulate farmers to implement these measures.

6.5 Conclusions

We developed a simulation model to estimate the effects of different measures for sow husbandry on animal welfare, farm income at farm level and citizens' attitudes. With this model the different effects can be integrated and overall efficiencies can be calculated. This study is the first that integrated these effects.

Results show that the effects of the defined measures to improve animal welfare in sow husbandry were different for animal welfare, farm income and citizens' attitudes. This means that one effect cannot predict the other effects. These results indicate that it is essential to use a more comprehensive approach for evaluating animal welfare measures that integrates animal welfare, farm income and citizens' attitudes. The most efficient measure in this study, i.e., 'straw provision, daylight and increased group size for gestating sows', still had a rather low effect on citizens' attitudes. To determine measures with a higher effect on these attitudes further research is necessary. For this research the present paper provides a basis.

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Appendix 6.1

Inputs for the economic module of the simulation model; inputs for the default situation and the increase or decrease in inputs compared to the default situation and the variation (Var) per measure for sow husbandry.

	Input	Adjusted inputs per measure and their variation															
Input name	Default	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var
Technical numbers																	
Labor (hours/year)	3120	[b]															
Company size (sow places)	440																
Occupation (% sows/sow places)	91																
Number of litters (sow/year)	2.36																
Litter size (live piglets/litter)	13.8																
Piglet mortality (%)	13	-1.00	0.50	-0.80	0.50	-0.60	0.50	-0.60	0.50								
Replacement breeding sows (%)	43																
Selection sow first insemination (%)	5																
Sow feed intake (kg/sow/year)	1165	13.60	6.66	10.70	6.88	8.20	6.70	8.20	6.70								
Piglet feed intake (kg/piglet)	28.2																
Buildings and inventory																	
Investment building/inventory	2500																
Depreciation period investment	20																
Residual value (€/sow place)	0																
Market interest (%)	6																
Maintenance (% of investment)	1.5																
Prices																	
Sow price (€/sow)	163																
Breeding sow price (€/sow)	250																
Selected breeding sow (€/sow)	121.2																
Sow feed (€/100 kg)	23.5																
Piglet price (€/piglet)	43																
Piglet feed (€/100 kg)	35																
Labor (€/hour)	22.85																

Other costs																	
Health care (€/sow/year)	69											1.13	0.05	0.8	0.04	0.80	0.13
Transport costs piglets (€/piglet)	27																
Heating (€/sow/year)	29																
Lighting (€/sow/year)	2.7																
Pen adjustments (€/sow/year)	0					0.67	0.01							0.3	0.01		
Cameras (€/sow/year)	0	1.77	0.09														
Jute bag (€/sow/year)	0			4.33	0.22												
Straw (€/sow/year)	0					0.08	0.01							2.5	0.13	0.27	0.01
Environm. enrichment (€/sow/year)	0											0.85	0.04				
Pain relief tail docking (€/sow/year)	0									1.45	0.0						
Other costs (€/sow/year)	60																
Time management (h/sow/year)																	
Cleaning sow pen	0.30																
Cleaning farrowing pen	0.23																
Cleaning farrowing pen after	3.22																
Cleaning weaned piglet pen	0.18																
Tail docking	0.92																
Time checks piglets first 2 days	0.30	0.06	0.00														
Time other tasks (hours/sow/year)	5.22			0.03	0.00			0.10	0.00	0.09	0.0	0.24	0.03	0.1	0.01	0.15	0.01

[a] Measure abbreviations: PM: piglet mortality, TB: tail biting, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets.

[b] When no value is given it was assumed to be the same value as in the default situation.

Input name	Input Default	Adjusted inputs per measure and their variation							
		μ	*Var*	*μ*	*Var*	*μ*	*Var*	*μ*	*Var*
Technical numbers									
Labor (hours/year)	3120	[b]							
Company size (sow places)	440								
Occupation (% sows/sow places)	91								
Number of litters (sow/year)	2.36								
Litter size (live piglets/litter)	13.8								
Piglet mortality (%)	13								
Replacement breeding sows (%)	43								
Selection sow first insemination (%)	5								
Sow feed intake (kg/sow/year)	1165								
Piglet feed intake (kg/piglet)	28.2								
Buildings and inventory									
Investment building/inventory	2500								
Depreciation period investment	20								
Residual value (€/sow place)	0								
Market interest (%)	6								
Maintenance (% of investment)	1.5								
Prices									
Sow price (€/sow)	163								
Breeding sow price (€/sow)	250								
Selected breeding sow (€/sow)	121.2								
Sow feed (€/100 kg)	23.5								
Piglet price (€/piglet)	43								
Piglet feed (€/100 kg)	35								
Labor (€/hour)	22.85								
Other costs									
Health care (€/sow/year)	69	-6.90	0.39	-4.80	0.27	-4.10	0.15	-6.20	0.32
Transport costs piglets (€/piglet)	27								
Heating (€/sow/year)	29								
Lighting (€/sow/year)	2.7					1.76	0.77	1.76	0.05

Pen adjustments (€/sow/year)	0	7.31	0.37			2.50	0.12	12.74	0.64
Cameras (€/sow/year)	0								
Jute bag (€/sow/year)	0								
Straw (€/sow/year)	0			3.99	0.20	3.99	0.20	3.99	0.20
Environm. enrichment (€/sow/year)	0								
Pain relief tail docking (€/sow/year)	0								
Other costs (€/sow/year)	60								
Time management (h/sow/year)									
Cleaning sow pen	0.30	0.15	0.00	0.08	0.00	0.08	0.00	-0.22	0.01
Cleaning farrowing pen	0.23								
Cleaning farrowing pen after	3.22								
Cleaning weaned piglet pen	0.18								
Tail docking	0.92								
Time checks piglets first 2 days	0.30								
Time other tasks (hours/sow/year)	5.22			0.15	0.01	0.15			

[a] Measure abbreviations: IH: indoor housing gestating sows, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.

[b] When no value is given it was assumed to be the same value as in the default situation.

Appendix 6.2

Animal welfare inputs for the simulation model; the animal welfare scores (AWS) per feature for the default situation and the increase or decrease in AWS compared to the default situation and the variation (Var) per measure for sow husbandry.

	AWS[a]	Increase or decrease in AWS per measure and their variation															
Feature	**Default**	*μ PM1*[b]	*Var*	*μ*	*Var*	*μ*	*Var*	*μ*	*Var*	*μ*	*Var*	*μ TB2*	*Var*	*μ TB3*	*Var*	*μ TB4*	*Var*
Water supply	87.5	[c]															
Number sows per drinking spot	100																
Bursitis	60																
Absence manure body sow	69.5																
Absence manure body piglet	69.5													10.3	5.1	10.3	5.1
Shoulder sores sow	95.0					3.5	1.5										
Surface per sow	12.5																
Group size	20																
Lameness sow	90																
Lameness piglet	90											5.0	2.0	1.0	1.0	5.0	2.0
Body wounds sow	79.8																
Body wounds piglet	98.8											-18.7	5.3	-12.6	5.4	-10.6	5.4
Vulva lesions sow	89.9																
Mortality sow	95																
Mortality piglet	87	1.0	0.2	0.8	0.1	0.6	0.1	0.6	0.2								
Tail docking	0									25.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
Positive social behavior sow	3							1.0	1.0								
Positive social behavior piglet	8													4.0	2.0	1.0	0.5
Negative social behavior sow	95							1.0	1.0								
Negative social behavior piglet	88											2.0	2.0	4.0	2.0	2.0	2.0
Stereotypies sow	60																
Explorative behavior sow	48			12.0	5.0	12.0	5.0										
Explorative behavior piglet	52											18.0	5.0	28.0	10.0	13.0	10.0
Human-animal relation score	16.7							58.1	5.2								
Human-animal relation score	1.95											5.6	4.3	11.8	4.2	16.1	4.5

Qualitative Behavioral Assessment (QBA) score sow	18.8		12.5	6.3	12.5	6.3	12.5	6.3								
Qualitative Behavioral Assessment (QBA) score piglet	18.8									25.0	6.3	37.5	6.3	25.0	6.3	

[a] Animal welfare scores were given on a scale of 1 (worst for animal welfare) to 100 (best for animal welfare).
[b] Measure abbreviations: PM: piglet mortality, TB: tail biting, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area.
[c] When no value is given it was assumed to be the same value as in the default situation.

	AWS[a]	Increase or decrease in AWS per measure and their variation							
Feature	Default	*μ HS1*[b]	*Var*	*μ*	*Var*	*μ*	*Var*	*μ HS4*	*Var*
Water supply	87.5	[c]						7.5	0.0
Number sows per drinking spot	100							-23.0	0.0
Bursitis	60	20.0	10.0	15.0	10.0	15.0	10.0	15.0	10.0
Absence manure body sow	69.5	10.2	5.2	7.2	5.0	7.2	5.0	7.2	5.0
Absence manure body piglet	69.5								
Shoulder sores sow	95.0								
Surface per sow	12.5	40.8	0.0						
Group size	20							80.0	0.0
Lameness sow	90	5.0	3.0	5.0	3.0	5.0	3.0	5.0	3.0
Lameness piglet	90								
Body wounds sow	79.8	10.2	5.2	5.1	3.0	5.1	3.0	10.2	5.2
Body wounds piglet	98.8								
Vulva lesions sow	89.9	8.1	1.0	8.1	1.0	8.1	1.0	6.0	2.0
Mortality sow	95	2.0	0.0						
Mortality piglet	87								
Tail docking	0								
Positive social behavior sow	3	3.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0
Positive social behavior piglet	8								
Negative social behavior sow	95	3.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0
Negative social behavior piglet	88								
Stereotypies sow	60	5.0	5.0	30.0	15.0	30.0	15.0	32.0	15.0
Explorative behavior sow	48	32.0	10.0	22.0	10.0	22.0	10.0	32.0	10.0
Explorative behavior piglet	52								
Human-animal relation score	16.7	32.4	10.2	22.1	6.1	19.1	3.1	35.5	7.3
Human-animal relation score	1.95								
Qualitative Behavioral Assessment (QBA) score sow	18.8	43.8	6.3	37.5	6.3	37.5	6.3	43.8	6.3
Qualitative Behavioral Assessment (QBA) score piglet	18.8								

[a] Animal welfare scores were given on a scale of 1 (worst for animal welfare) to 100 (best for animal welfare).

[b] Measure abbreviations: IH: indoor housing gestating sows, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.

[c] When no value is given it was assumed to be the same value as in the default situation.

Appendix 6.3

Inputs for the attitude module; the mean negative attitude (NA) levels per aspect for the default situation and the increase or decrease in NA levels compared to the default situation and the variation (Var) per measure for sow husbandry.

	NA[a]	Increase or decrease in NA per measure and their variation															
Aspect	Default	μ PM1[b]	Var	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var	μ	Var
Animals																	
Disease/infection/injuries	3.8	-0.8	0.3	-0.3	0.2	-0.6	0.3	-0.2	0.1	-0.8	0.3	-0.5	0.3	-0.8	0.5	-0.8	0.5
Mortality	3.6	-0.8	0.3	-0.3	0.2	-0.6	0.3	-0.5	0.3	-0.5	0.3	-0.2	0.1	-0.5	0.3	-0.5	0.3
Fear/anxiety	3.8	-0.8	0.3	-0.8	0.3	-0.6	0.3	-0.2	0.1	-1.3	0.4	-0.8	0.3	-1	0.4	-0.8	0.3
Pain	3.9	-0.8	0.3			-0.6	0.3	-0.2	0.1	-0.8	0.4	-0.8	0.3	-1	0.5	-0.8	0.3
Number of kept animals	3.9	-0.25	0.25									-0.6	0.3	-0.5	0.2	-0.4	0.2
Environmental enrichment	3.6	[c]		-0.4	0.15	-0.7	0.5					-0.7	0.3	-1.2	0.5	-0.8	0.4
Number of animals per m2	3.9											-0.6	0.3			-0.6	0.3
Floor cover	3.8					-0.7	0.5							-1.2	0.5	-1	0.4
Possibility of going outside	4.0																
Tail docking	3.7									-1	0.5	-2.1	0.5	-2.1	0.5	-2.1	0.5
Number of litters per sow	3.6	-0.25	0.25									-0.2	0.1	-0.3	0.1	-0.2	0.1
Litter size	3.6	-0.25	0.25					-0.2	0.1			-0.2	0.1	-0.3	0.1	-0.2	0.1
Care for individual animal	3.8	-0.8	0.3	-0.2	0.1	-0.5	0.3			-0.6	0.3	-1.2	0.5	-1.3	0.5	-1	0.5
Humans																	
Enough income	3.6									0.15	0.15			0.2	0.15	0.1	0.1
Working conditions	3.5													0.15	0.15	0.1	0.1
Health risks	3.8																
Physical burdon	3.5																
Product price	3.3	0.15	0.15							0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Freedom of choice	3.4																
Food safety risks	4.0									0.1	0.1						
Public health risks	4.0																

Environment	
Environmental waste	4.0
Smell	3.6
Change in infrastructure	3.7
Image landscape	3.6

[a] Negative attitude levels are on a scale of 1 (no negative attitude) to 5 (maximum negative attitude).
[b] Measure abbreviations: PM: piglet mortality, TB: tail biting, IH: indoor housing gestating sows, PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, PM4: sow habituation, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, TB4: chopped straw provision for weaned piglets, IH1: free range outside area, IH2: straw provision, IH3: straw provision and window, IH4: straw provision, window and increased group size.
[c] When no value is given it was assumed to be the same value as in the default situation.

Aspect	NA Default	μ HS1	Var HS1	μ HS2	Var HS2	μ HS3	Var HS3	μ HS4	Var HS4
Animals									
Disease/infection/injuries	3.8	-1.2	0.5	-0.4	0.2	-0.5	0.3	-0.8	0.5
Mortality	3.6	-1.2	0.5	-0.4	0.2	-0.5	0.3	-0.8	0.5
Fear/anxiety	3.8	-1.5	0.5	-0.4	0.2	-0.5	0.3	-1	0.5
Pain	3.9	-1.2	0.5	0	0	0	0	-0.8	0.5
Number of kept animals	3.9	-1.2	0.8	0	0	0	0	-1	0.5
Environmental enrichment	3.6	-1.8	0.5	-0.6	0.4	-0.8	0.5	-1.2	0.5
Number of animals per m2	3.9	-1.5	0.5	-0.4	0.3	-0.5	0.3	-1	0.5
Floor cover	3.8	-1.5	0.5	-0.8	0.6	-1	0.5	-1	0.5
Possibility of going outside	4.0	-3	0.8					-1.5	0.5
Tail docking	3.7								
Number of litters per sow	3.6								
Litter size	3.6								
Care for individual animal	3.8	-1.5	0.5	-0.6	0.4	-0.8	0.5	-1.2	0.5
Humans									
Enough income	3.6	0.5	0.3	0.15	0.15	0.15	0.15	0.1	0.1
Working conditions	3.5	0.4	0.3	0.15	0.15	0.15	0.15	0.2	0.1
Health risks	3.8								
Physical burdon	3.5			0.15	0.15	0.15	0.15	0	0.3
Product price	3.3	0.8	0.5	0.3	0.1	0.3	0.1	0.2	0.1
Freedom of choice	3.4	-0.5	0.3	0.3	0.1	0.3	0.1	-0.3	0.1
Food safety risks	4.0								
Public health risks	4.0	0.6	0.4						
Environment									
Environmental waste	4.0	0.4	0.2						
Smell	3.6	0.7	0.5						
Change in infrastructure	3.7	-0.3	0.6						
Image landscape	3.6	-0.3	0.6						

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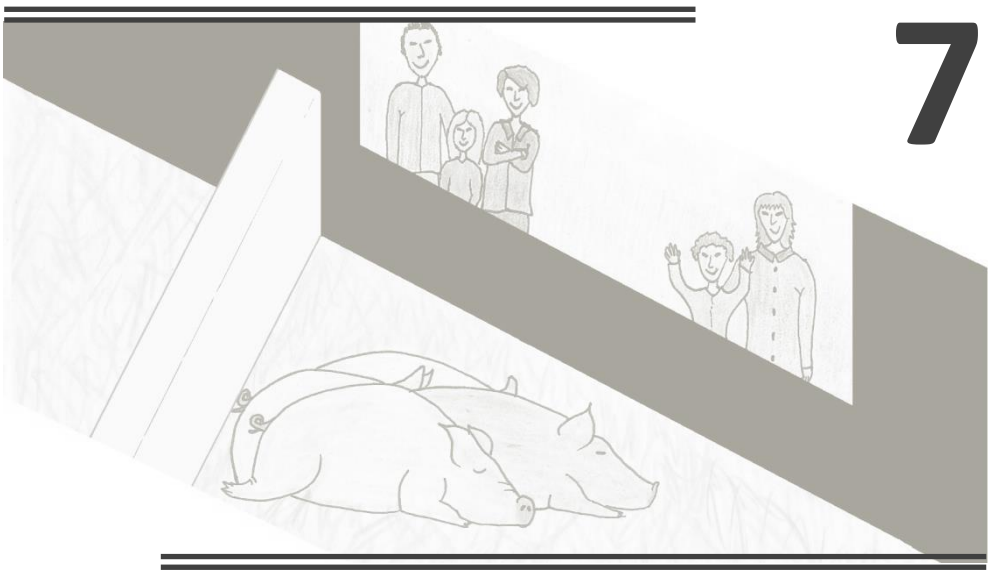

7

General discussion

7.1 Introduction

In current Western societies, citizens are concerned about animal welfare in animal husbandry systems (Boogaard et al., 2011a; Boogaard et al., 2011b; Harper and Henson, 2001; Ingenbleek et al., 2004; Meuwissen and van der Lans, 2005; Norwood and Lusk, 2009; Rollin, 2004; Verbeke and viaene, 2000). Animal husbandry has changed drastically since World War II because changing policies in Western societies aimed for the production of plentiful meat of good quality and low prices (Fraser et al., 2001; Rollin, 2004). This is when traditional animal husbandry changed into intensive animal husbandry which aims for productivity and efficiency and which changed the way animals are kept (Fraser et al., 2001; Rollin, 2004). Intensification resulted in less involvement of citizens with animal husbandry because less people were working within animal husbandry (Fraser et al., 2001; Marchant-Forde, 2009; Rollin, 2004) and the change from open farms to closed farms where animals are kept indoor behind closed doors (Van der Meulen et al., 2011). The lower involvement of citizens increased the distance between citizens and animal husbandry which led to a change in the relationship between citizens and animal husbandry (Fraser et al., 2001; Marchant-Forde, 2009; Rollin, 2004) and a change in moral values with regard to animal husbandry (Rollin, 1994). Based on the change in these values, such as the believe that animals are sentient beings and that humans should do good to all animals (Cohen et al., 2012), law and legislation has been established, inter alia in the European Union (European Union, 2014) and in the Netherlands (Overheid, 2014), to improve animal welfare. Although farmers adhere to these laws and legislations there is a lot of societal discussion about animal welfare in animal husbandry because many citizens hold negative attitudes toward this system.

In the Netherlands, one of the animal husbandry systems that is struggling with negative citizens' attitudes is sow husbandry (Kanis et al., 2003). The pig sector tries to positively influence citizens' attitudes by introducing measures to improve animal welfare. However, these measures focus on measurable physical welfare of animals (Beekman et al., 2002) and on a single issue, such as piglet mortality. For example, to lower piglet mortality the measure 'motherless-rearing' was introduced. Although these measures aim for animal welfare improvement, they are unsuccessful in improving citizens' attitudes toward sow husbandry. This means that there is a discrepancy between the effect of these measures on animal welfare and on citizens' attitudes. Citizens' attitudes toward sow husbandry keep changing because of changing societal moral values (Chrispeels and Mandoli, 2003; Rollin, 2004), changes in socio-demographic features within society (Frederiksen et al., 2010; Harper and Henson, 2001; Herzog, 2007; Knight et al., 2004; María, 2006; Prickett et al.,

2010; Tuyttens et al., 2010; Vanhonacker et al., 2010) and sudden impacts, such as an outbreak of classical swine fever (Beekman et al., 2002; Elzen et al., 2011; Kanis et al., 2003). The constantly changing citizens' attitudes toward sow husbandry create a challenge for the pig sector to respond to these attitudes. Moreover, in responding to citizens' attitudes, the sector has to take into account the effect of measures to improve animal welfare on their farm income. This means that farm income, animal welfare and citizens' attitudes all play a role in measures to improve animal welfare in sow husbandry and that the development of new measures requires an interdisciplinary approach (Bennett, 1997; McGlone, 2001; Mellor and Stafford, 2001). Therefore, the main objective of this thesis was to estimate the effects of measures to improve animal welfare in sow husbandry in the Netherlands on animal welfare, farm income and citizens' attitudes. This thesis was directed to issues of Dutch sow husbandry that appeared several times in the media from 2009 until 2011, including piglet mortality, pig housing, scale increase, castration, tail docking, sow lifespan, piglet litter size, weaning age piglets, motherless care of piglets and the use of antibiotics in pigs (Varkens in nood, 2010; Wakker dier, 2010). To reach the main objective, the thesis was divided into five sub objectives, and the findings with regard to these objectives are described in the previous chapters (2-6). These findings will be synthesized in this chapter and compared with previous studies. Furthermore, this chapter will verify the estimated effects of measures to improve animal welfare in sow husbandry on citizens' attitudes. Also the implications for the pig sector with regard to measure implementation will be discussed. The last part of this chapter presents the main conclusions of this thesis and recommendations.

7.2 Synthesis

Citizens' attitudes toward sow husbandry often stay negative after the introduction of measures to improve animal welfare in sow husbandry. Hence, these measures have a different effect on citizens' attitudes than the pig sector expects a priori. The difference between the expectations of the Dutch pig sector and the actual effect of the measures on Dutch citizens' attitudes in the last decades might be attributed to different attitudes between stakeholders of sow husbandry and citizens. Chapter 2 and 3 showed that there are differences in attitudes of stakeholders of sow husbandry, i.e., citizens, pig farmers (conventional and organic), pig veterinarians and pig husbandry advisors. Attitudes are based on ethical values (Rokeach, 1968-1969), which could mean that a difference in attitudes between stakeholders can be predicted by ethical values. However, Chapter 4

concluded that basic values related to sow husbandry are not a good predictor of attitudes toward sow husbandry but that basic values can be used to bridge the gap in attitudes toward sow husbandry between citizens and conventional pig farmers. Results of Chapter 3 show that citizens have negative attitudes toward sow husbandry with respect to animal welfare and conventional pig farmers have negative attitudes toward sow husbandry with respect to income for the animal keeper and price of the products for consumers. This indicates that both animal welfare and farm income are important in measures to improve animal welfare in sow husbandry. Chapter 5 focused on the effects of these measures on animal welfare and farm income. For the effect of measures to improve animal welfare in sow husbandry on citizens' attitudes, Chapter 6 focused, next to the effects on animal welfare and farm income, on the effect of these measures on citizens' attitudes. For these attitude effects, the focus was on the aspects of sow husbandry that are described in Chapter 2 and 3.

Attitudes toward sow husbandry

The findings in Chapter 2 showed that citizens' attitudes toward the entities 'animals', 'humans' and 'environment' were all important in their judgment of sow husbandry. With respect to all relevant aspects of the three entities, on average, citizens' attitudes toward sow husbandry were negative. The most negative attitudes were found with respect to the effect of the use of antibiotics on animals and consumers, the number of animals kept per square meter, the possibility for animals to go outside, food safety risks, public health risks and environmental waste. This confirms that not only animal welfare is important in citizens' judgment of sow husbandry, but also aspects related to humans and the environment (Boogaard et al., 2011b; Kanis et al., 2003; Meuwissen and van der Lans, 2005). Previous studies also indicated that the aforementioned entities are important in society's judgment of sow husbandry (Beekman et al., 2002; Blokhuis et al., 2003; Harper and Henson, 2001; Mepham, 2000). However, as far as known, no studies included a broad selection of relevant aspects related to these entities in determining attitudes toward sow husbandry. There are studies that found negative citizens' attitudes toward one aspect, for example, the effect of the use of antibiotics on humans (Frederiksen et al., 2010; Huber-Eicher and Spring, 2008), or toward a few aspects, such as animal housing, food safety and environmental waste with regard to pig husbandry (Boogaard et al., 2010; Meuwissen and van der Lans, 2005). By including a broad selection of relevant aspects related to animals, humans and the environment with regard to sow husbandry, Chapter 2 gave a more complete representation of attitudes that determine citizens' judgment of sow husbandry.

Based on their attitudes toward sow husbandry, citizens were divided into four clusters (Chapter 2). The two smallest clusters were the cluster with no negative attitudes toward sow husbandry (no-AC cluster; 7% of respondents) and the cluster with the highest negative attitudes toward sow husbandry (max-AC cluster; 14% of respondents). These clusters were most distinctive in their attitude scores as well as in their socio-demographic features, such as gender, eating meat and whether they had visited a pig farm, compared to the other two clusters that had negative attitudes toward sow husbandry. The findings on gender correspond to previous studies (Frederiksen et al., 2010; Harper and Henson, 2001; Herzog, 2007; Knight et al., 2004; María, 2006; Prickett et al., 2010; Tuyttens et al., 2010; Vanhonacker et al., 2010) in which it was found that females are more critical about animal welfare and the use of animals than males (cluster with high negative attitudes). The findings with regard to eating meat correspond to the study of Knight et al. (2004) in which it was found that people who eat meat support the use of animals more than people who do not eat meat (cluster with no negative attitudes). Where people grew up and whether they ever visited a pig farm can be connected to knowledge of and commitment to sow husbandry (Boogaard et al., 2006). This knowledge and commitment have an effect on attitudes toward sow husbandry (Boogaard et al., 2011b; Boogaard et al., 2006). More respondents in the cluster with no negative attitudes more often grew up in small non-urban villages and more often had visited a pig farm than respondents in the other clusters. This suggests that people with no negative attitudes toward sow husbandry have more knowledge of and commitment to this animal practice than other people. The different clusters with different socio-demographic features indicate that there are different types of citizens' when it comes to attitudes toward sow husbandry but that there is only a small group that has no negative attitudes.

The data of citizens' attitudes toward aspects of animals, humans and the environment with regard to sow husbandry that are presented in Chapter 2, were used in Chapter 3 to compare attitudes of different stakeholders of sow husbandry, i.e., citizens, conventional pig farmers, organic pig farmers, pig veterinarians and pig husbandry advisors. Findings in Chapter 3 show that stakeholders can be divided in three distinctive groups based on their attitudes toward sow husbandry. The group of citizens and organic pig farmers showed negative attitudes toward sow husbandry with respect to all defined aspects. Previous studies also found similarities between these groups in that both groups define animal welfare based on the physical and mental health of the animals (Bock et al., 2007; Te Velde et al., 2002). Based on the results of this thesis it can be stated that citizens and organic pig farmers share not only the judgment of animal welfare, but also the judgment of humans and the environment with regard to sow husbandry. The group of conventional pig farmers

and pig husbandry advisors showed negative attitudes toward sow husbandry with respect to only economic aspects, i.e., enough income of the farmer and the price of meat products for consumers. Previous studies also showed that there are differences between conventional pig farmers and citizens and between conventional pig farmer and organic pig farmers in their judgment of animal welfare (Bock et al., 2007; Bracke et al., 2005; Te Velde et al., 2002; Vanhonacker et al., 2008). Conventional pig farmers define animal welfare based on physical health and production (Bock et al., 2007; Bracke et al., 2005; Van Huik and Bock, 2007) and are in general more positive about animal welfare than citizens (Te Velde et al., 2002; Vanhonacker et al., 2008) and organic pig farmers (Van Huik and Bock, 2007). Results of this thesis show that pig farm advisors share the same attitudes toward sow husbandry as conventional pig farmers, which has not been shown before. The third group was the group of pig veterinarians, who sometimes differed in attitudes from the other two groups and sometimes shared attitudes with these groups. For example, pig veterinarians shared attitudes toward sow husbandry with conventional pig farmers and pig husbandry advisors with respect to economic aspects and with citizens and organic pig farmers with respect to several aspects related to the animal, e.g., pain and lifespan sow. No previous studies compared attitudes toward animal husbandry of veterinarians with other stakeholders.

The difference in attitudes toward sow husbandry of the three aforementioned groups indicates that they judge sow husbandry from different perspectives. From the perspectives of conventional pig farmers and pig husbandry advisors, the economic effects on their business are considered in their attitudes toward each aspect of sow husbandry. This means that these groups will consider the possibilities, including the economic consequences, within their business with regard to an aspect before they form an attitude toward that aspect. Based on the economic consequences, they find it acceptable to keep pigs indoor. From the perspective of citizens, each aspect of sow husbandry seems to be important on its own and they do not seem to link the different aspects in their judgment of sow husbandry. The perspective of pig veterinarians is based on measurable facts and they judge pig husbandry on physiological and productive characteristics of the animals. In their judgment, pig veterinarians probably also consider the effects on the animal keeper.

Differences between stakeholders were also found in the acceptability of issues of sow husbandry, such as piglet mortality, castration and indoor housing (Chapter 3). Most of these issues were found to be acceptable by conventional pig farmers and pig husbandry advisors. For some of the issues, namely piglet mortality, weaning age and lifespan sow, most citizens indicated to have no opinion. This implies that citizens are realistic when it comes to knowledge; if they do not have knowledge of the issue they do not judge. About

some of the issues, such as castration and indoor housing, citizens seemed to have knowledge as they indicated to find these issues unacceptable.

Basic values and attitudes

Basic values underlie attitudes (Rokeach, 1968-1969). As attitudes toward sow husbandry differ between citizens and conventional pig farmers (Chapter 3) (Bracke et al., 2005; Petit and van der Werf, 2003; Te Velde et al., 2002; Tuyttens et al., 2010; Vanhonacker et al., 2008), it could be possible that basic values related to sow husbandry also differ between these groups. Chapter 4 focused on the relation between these basic values and attitudes toward sow husbandry of citizens and conventional pig farmers. To the best of the author's knowledge, there are no previous studies that made this connection with regard to sow husbandry. Cohen et al. (2010a) did study moral convictions and the judgment on culling healthy animals. They included a wide range of moral values that play a role in the judgment of animal husbandry, such as animal value and human-animal hierarchy. Based on these moral values, citizens were divided in two groups and these groups were compared in their judgment on culling healthy animals (Cohen et al., 2012). However, moral values were not connected to the different attitudes that play a role in the judgment of culling healthy animals. By including the wide range of attitudes of citizens and conventional pig farmers as described in Chapter 2 and 3, combined with a wide range of basic values, it was possible to study the potential link between basic values and attitudes toward sow husbandry.

In Chapter 4 it is shown that basic values related to sow husbandry of citizens and conventional pig farmers cannot one-on-one predict attitudes toward sow husbandry of these groups. Basic values of conventional pig farmers were mostly shared by citizens as one group. This corresponds to previous studies (Cohen et al., 2010b, 2012) in which it was found that moral values toward animal husbandry were shared by Dutch citizens and farmers. The difference in attitudes toward sow husbandry between citizens and conventional pig farmers may be caused by differences in the interpretation and weighting of basic values. Chapter 4 shows that the two groups interpret naturalness differently. Citizens indicated to find the constituents 'possibility to go outside' and 'possibility to grub and mud bathe' of naturalness important, while pig farmers did not find these constituents important. These constituents were correlated (correlation > 0.6) to the basic value 'living conditions should be natural', which means that these constituents of naturalness play an important role for citizens in their basic values related to sow husbandry. For pig farmers these constituents are less or not important. The possibility to go outside and the possibility

to grub and mud bathe can be seen as important for pigs to have freedom of movement and the possibility to perform natural behavior, which were shown to be important for both citizens and conventional pig farmers (Chapter 4, Te Velde (2002), Boogaard 2011b). Pig farmers might interpret and weigh basic values different than citizens.
Although citizens as one group shared most of the basic values with conventional pig farmers, there were some differences in basic values between the four clusters of citizens as defined in Chapter 3, and conventional pig farmers. The basic values of conventional pig farmers were mostly shared by citizens in two of the four clusters, including the moderate-AC cluster, but citizens in the other two cluster differed in seven out of twelve basic values from conventional pig farmers. The two latter clusters share some basic values with citizens in the moderate-AC cluster. This makes the moderate-AC cluster a useful cluster for pig farmers to learn to understand citizens' basic values and bridge the gap in attitudes toward sow husbandry between them and society.

Effects of measures to improve animal welfare in sow husbandry

Because of the interest of citizens in animal welfare (Chapter 2 and 3) and the interest of farmers in farm income (Chapter 3), the effect of measures for sow husbandry on these two disciplines could provide more insight in the effectiveness of these measures. In Chapter 5, different measures to improve animal welfare in show husbandry were defined. These measures were related to issues that were found to be unacceptable by most citizens (Chapter 3; piglet mortality, tail biting or indoor housing of gestating sows). Findings in Chapter 5 show that an improvement of animal welfare is not always accompanied by a negative effect on farm income. Previous studies on economic effects of animal welfare improvement of different types of farm animals are in line with this (Bruijnis et al., 2013; Cain and Guy, 2006; Stott et al., 2012). Chapter 5 shows that it is possible to improve animal welfare while increasing net farm income, which was the case for the defined measures to decrease piglet mortality. This suggests that it is profitable for pig farmers to implement one of these measures. Bornett et al. (2003) also stated that it is possible to improve animal welfare in pig housing systems without losing net farm income. The measures with a positive effect on net farm income were also the measures with the highest cost-effectiveness with regard to animal welfare and net farm income (Chapter 5). Compared to these measures, the cost-effectiveness of measures to improve indoor housing of gestating sows ('free range outside area' and 'increased group sizes with straw provision and daylight') was lower because of the negative effect on net farm income. However, their effect on animal welfare was relatively high, possibly because the relatively

high contribution to social behavior of sows. Previous studies have shown that a larger surface area provides sows the possibility to avoid conspecifics which has a positive effect on social behavior and consequently on animal welfare (Gonyou, 2001). Because of their relatively high positive effect on animal welfare, the cost-effectiveness of the measures 'free range outside area' and 'increased group sizes with straw provision and daylight' were relatively high compared to some of the measures with approximately the same or a lower effect on farm income (Chapter 5). This means that just the single effect on either animal welfare or net farm income gives a different outcome of the effectiveness of measures than a combination of these effects.

Measures that are developed to improve animal welfare in sow husbandry focus on animal welfare and net farm income but do not succeed in improving citizens' attitudes toward sow husbandry as these attitudes remain negative (Aarts et al., 2001; De Greef et al., 2006; Meuwissen and van der Lans, 2005; Chapter 2). Therefore, it is important to include the effect of measures to improve animal welfare in sow husbandry on citizens' attitudes toward sow husbandry, next to the effect on animal welfare and farm income. In Chapter 6, the effect of these measures on citizens' attitudes is analyzed in addition to the effects on animal welfare and farm income. The measures that were defined in Chapter 5 were compared in these effects. Findings of Chapter 6 show that the measure that is most efficient based on the combined effects on animal welfare, farm income and citizens' attitudes ('straw provision, daylight and increased group size' for gestating sows) is not the same as the measure that is most cost-effective with regard to animal welfare and farm income ('camera surveillance farrowing pen', Chapter 5). This indicates that it is essential to include the effect on citizens' attitudes next to the effect on animal welfare and farm income in order to decide which measures to improve animal welfare in sow husbandry are most efficient. The effect on citizens' attitudes was relatively high for the measure 'straw provision, daylight and increased group size' compared to the measure 'camera surveillance farrowing pen'. This higher effect might be explained by previous findings that citizens find it important that animals have daylight and space (Boogaard et al., 2011b).

Chapter 6 shows that there is much variation in the effect of measures to improve animal welfare in sow husbandry on citizens' attitudes. This variation is due to several factors that influence attitudes, such as socio-demographic features (Chapter 2) (Boogaard et al., 2006; Knight and Barnett, 2008; Knight et al., 2004), personal interests (Boogaard et al., 2006; Bracke et al., 2005; Te Velde et al., 2002) and the media (Boogaard et al., 2011a; Boogaard et al., 2006; Knight and Barnett, 2008). These factors make it difficult to predict the effect of these measures on citizens' attitudes.

The results of Chapter 6 show that it is important to integrate the effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes to calculate efficiencies because an improvement of, for example, animal welfare does not necessarily result in an improvement of citizens' attitudes and a decrease in farm income. This means that the one effect of a measure cannot predict the other effects.

7.3 Interdisciplinary approach

Throughout this thesis different interdisciplinary approaches have been used with regard to methods and disciplines. The different approaches will be discussed in this section.

Conceptual approach

Previous studies have indicated that several aspects, related to different entities, i.e., animals, humans and the environment, play a role in attitudes toward animal husbandry (Blokhuis, 2008; Blokhuis et al., 2003; Kanis et al., 2003). This implies that an interdisciplinary approach is needed to get a complete overview of these attitudes. Some studies included a selection of the aspects (Boogaard et al., 2011b; Harper and Henson, 2001; Krystallis et al., 2009; Meuwissen and van der Lans, 2005). However, none of these studies included a wide range of aspects, related to the three entities, that are relevant for attitudes toward sow husbandry. In this thesis, a wide range of these relevant aspects are included. This provides a more complete overview of attitudes that are important in the judgment of sow husbandry. For an overview of aspects that are relevant for attitudes toward sow husbandry, a framework was developed. This framework consists of two parts. One part includes aspects that are relevant for attitudes toward sow husbandry (Chapter 2). The other part of the framework includes ethical basic values that underlie attitudes toward sow husbandry (Chapter 4), because these values are important in forming attitudes (Rokeach, 1968-1969). This framework was the basis for the questionnaire that was developed for determining attitudes toward sow husbandry and basic values in relation to sow husbandry.

A novel interdisciplinary approach was used to get insight in the overall effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes. McGlone et al. (2001) mentioned that it is necessary to use an approach that includes the effects on animal welfare, farm income, environment and public perceptions, to decide if measures to improve animal welfare are efficient. Some studies included only animal welfare and farm income (Bornett et al., 2003; Bruijnis et al., 2012; Cain and Guy,

2006; Gocsik et al., 2013; Seddon et al., 2013; Stott et al., 2012; Vosough Ahmadi et al., 2011). In Chapter 5 this approach was also used, because the interests of citizens in animal welfare and the interest of pig farmers in farm income (Chapter 3) are both taken into account. However, with this approach the actual effect of measures to improve animal welfare in sow husbandry on citizens' attitudes are still unknown. No studies have been found that included the effects of animal welfare measures on both animal welfare, farm income and citizens' attitudes. Many studies based their research on citizens' negative attitudes toward animal welfare, and focused on animal welfare issues appointed by citizens (e.g., Gocsik et al., 2013 and Vosough Ahmadi et al., 2011). However, none of these studies considered the effect of animal welfare improvement on citizens' attitudes. For this thesis, a model was developed in which the effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes can be estimated (Chapter 6). Although the approach used in this thesis is interdisciplinary, it does not include all important dimensions of the problem. The environment is an important dimension that still needs to be addressed as well.

Survey

For Chapter 2, 3 and 4 an online survey was used to gain insight in attitudes and basic values of different stakeholders of sow husbandry. This online survey made it easier to survey groups that were otherwise difficult to reach (Wright, 2005), namely organic pig farmers, pig husbandry advisors and pig veterinarians. Umbrella organizations to which these stakeholders were connected were not willing to provide addresses or telephone numbers, but they were willing to send a link to the online survey in an electronic mail or in a general electronic newsletter.

A disadvantage of an online survey can be that the respondents are unknown and it is difficult to select a group that is representative (Wright, 2005). For the stakeholder groups other than the citizens, this was no problem because most pig farmers, pig husbandry advisors and pig veterinarians were registered at umbrella organizations. To get a representative sample of Dutch respondents, a research institute was invoked that was specialized in online surveys and had a directory of Dutch citizens representative for the Netherlands (CentERdata, Tilburg, the Netherlands).

The disadvantage of questionnaires is that it is inevitable to guide respondents at least a little bit. The questionnaire used for this thesis gave only minimal information on sow husbandry to prevent respondents from giving socially desirable answers. Questions with regard to specific issues of sow husbandry may have forced respondents to think in a

certain direction that may have never come to mind without these questions. The responses regarding attitudes toward sow husbandry may have been affected by this.

Modelling

In this thesis a mix of statistical, econometric, simulation and mathematical programming methods is used. To know whether citizens can be divided in different clusters based on their attitudes toward sow husbandry, a cluster analysis was applied (Chapter 2). Cluster analysis grouped citizens with more similar attitudes into four clusters. To test in which attitudes these clusters differed, ordered multinomial logistic regression was used. Binary logistic regression was used to compare these clusters in socio-demographic features, such as age, gender and education. With these regressions it was possible to use non-normal categorical data. Ordered multinomial logistic regression was also used to compare attitudes toward sow husbandry of different stakeholders, i.e., citizens, conventional pig farmers, organic pig farmers, pig husbandry advisors and pig veterinarians (Chapter 2), and the basic values of the four clusters of citizens and conventional pig farmers (Chapter 3). To test whether basic values of citizens and conventional pig farmers can predict one-on-one the attitudes towards sow husbandry of these groups, a Kendall's Tau rank correlation analysis was carried out. In Chapter 5 and 6 a simulation model was developed to gain insight in the effect of measures to improve animal welfare in sow husbandry, farm income and citizens' attitudes. The use of simulation models has proven to be useful in estimating the effects of animal welfare measures on farm income (Bruijnis et al., 2010; Cain and Guy, 2006; Den Ouden et al., 1997; Gocsik et al., 2013; Stott et al., 2012; Vosough Ahmadi et al., 2011). To test the sensitivity of the model outcomes for the estimated effects on animal welfare and farm income, sensitivity analysis was carried out (Chapter 5). In order to integrate the effects on animal welfare, farm income and citizens' attitudes, Data Envelopment Analysis (DEA) was used (Chapter 6). Often, DEA is used to assess the technical efficiency of different producers, such as pig farmers (Martić et al., 2009), but it is shown that it can also be used to compare the effects of different measures on a single farm (Huijps et al., 2010).

7.4 Verification effects measures on citizens' attitudes

The simulation models described in this thesis estimated the effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes. Because parameterization of the inputs of the model was based on different resources (e.g., literature and expert knowledge) and assumptions, it is not guaranteed that the estimated effects of these measures will be similar when the measures are actually applied in a sow farm. The estimated effects on animal welfare and farm income can be substantiated by previous studies on the effect of animal welfare improvement on farm income (e.g., Bornett et al., 2003; Cain and Guy, 2006; Seddon et al., 2013) and the assessment of animal welfare (e.g., Dalmau et al., 2009; Stott et al., 2012; Vermeer et al., 2012). By using previous estimates as a guide in estimating the effects of the defined measures on animal welfare and farm income, these estimates could be verified. Since there are no previous studies on estimating effects of animal welfare improvement on citizens' attitudes, it is impossible to verify these effects. Therefore, a limited verification of the estimates with regard to the effects of the defined measures on citizens' attitudes was done by means of an additional online questionnaire. The questionnaire was distributed online and could be filled in by Dutch citizens. Respondents were asked to indicate the effect on their overall attitudes toward sow husbandry after the implementation of one of the measures defined in this thesis (Chapter 5) in the reference sow farm described in this thesis (Chapter 5). They could indicate whether the measure had a negative effect, no effect or a positive effect from 1 (minor positive) to 5 (maximal positive) on their attitudes toward sow husbandry.

For all presented measures to improve animal welfare in sow husbandry, most respondents indicated that their overall attitudes toward sow husbandry would improve (Figure 7.1). The measure 'free range outside area' had on average the strongest positive effect on citizens' attitudes (Figure 7.1a). This result corresponds to the effect on attitudes that was estimated with the simulation model (Chapter 6). However, this was the only correspondence between the results of the verification questionnaire and the estimated results. When ranking the measures based on their average effect on citizens' attitudes, only the measure 'free range outside area' received the same rank in the estimated effects and the effects indicated by respondents to the verification questionnaire. Consequently, there was no rank correlation (Spearman's rho correlation 0.33; P=0.39) between the estimated effects and the indicated effects.

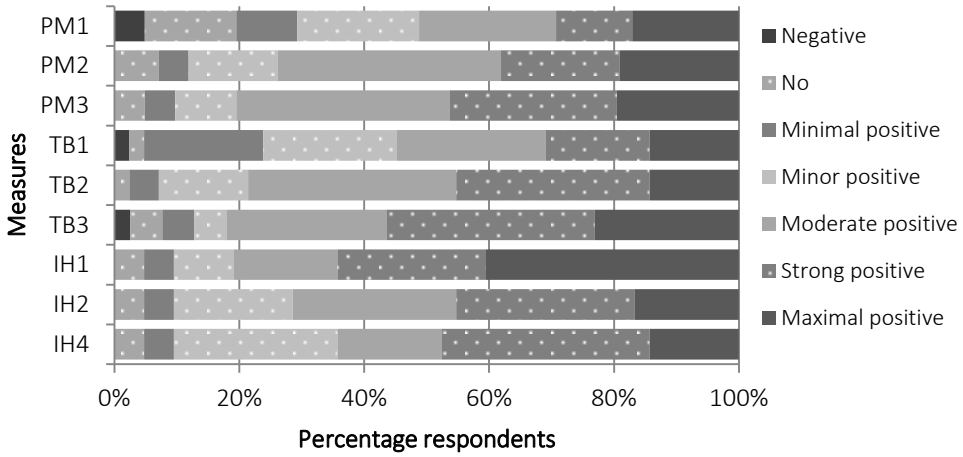

Figure 7.1 The percentage of respondents (n = 42) per effect on attitudes (negative effect, no effect, minimal positive effect, minor positive effect, moderate positive effect, strong positive effect and maximal positive effect) toward sow husbandry per measures to improve animal welfare in sow husbandry.
Measures: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, IH1: free range outside area, IH2: straw provision, IH4: straw provision, window and increase group size. (See Paragraph 5.2 for explanation of the measures).

Table 7.1 Ranking of measures to improve animal welfare in sow husbandry based on their average effect on citizens' attitudes based on the estimated effects (Chapter 6) and the effects indicated by respondents to the verification questionnaire. Rank 1 stand for the highest effect, followed by 2, etc.

Measure[a]	Estimated	Questionnaire
PM1	9	7
PM2	5	9
PM3	3[b]	7
TB1	8	5
TB2	2	4
TB3	7	2
IH1	1	1
IH2	3	6
IH4	5	2

[a] Measures: PM1: camera surveillance farrowing pen, PM2: jute sack provision sow, PM3: straw provision sow, TB1: tail docking with analgesia, TB2: biting material for weaned piglets, TB3: straw playing area for weaned piglets, IH1: free range outside area, IH2: straw provision, IH4: straw provision, window and increase group size.
[b] Two measures with the same number have the same (estimated) effect on citizens' attitudes.

In general, the levels of improvement of attitudes of respondents to the verification questionnaire were much higher than was estimated in Chapter 6. This higher impact could be due to socio-demographic features. This thesis (Chapter 3) and previous studies showed that education, age, gender and having visited an animal farm have an effect on attitudes toward animal husbandry (Frederiksen et al., 2010; Knight et al., 2004; Prickett et al., 2010). The respondents to the verification questionnaire were younger (74% < 44 years), mostly highly educated (BSc or MSc; 71%), mostly female (62%) and most had visited a pig farm at least once (67%), which were higher percentages than in the Dutch population. The estimated effects of measures to improve animal welfare in sow husbandry on citizens' attitudes were based on the Dutch population and may, therefore not match with the effect of these measures on a group of citizens with divergent socio-demographic features.
Another reason for the high impact of the defined measure on attitudes of respondents to the verification questionnaire can be the context of the question. Although it was stated in the questionnaire that respondent had to indicate the effect of the defined measures on their attitudes toward sow husbandry in general, it is possible that respondents only focused on the issue to which the presented measure was related. This means that respondents only thought of piglet mortality when a measure to decrease piglet mortality was presented and no longer thought about the rest of sow husbandry.

Results of the verification questionnaire suggest that it is difficult to estimate the effect of the defined measures on citizens' attitudes (Chapter 6). Although the results of the verification questionnaire cannot verify the estimated effects of the defined measures on citizens' attitudes, they do show that the attitudes of citizens improve when any of these measures will be implemented. Results also show that the measure with the highest effect on attitudes of respondents to the verification questionnaire was similar to the measure that was estimated to have the highest effect on citizens' attitudes. This suggests that, despite differences in socio-demographic features, such as age and education, citizens are in favor of the same measure, i.e., free range outside area. An explanation for this can be that, in general, citizens find naturalness important (Lassen et al., 2006; Verbeke, 2009), including the possibility for animals to go outside and to perform natural behavior (Chapter 4), which are both met with the defined measure.
If it is possible to determine the measure that is favored the most by citizens independently of socio-demographic features, the model presented in Chapter 6 is useful for any group of citizens. However, to verify this, groups of citizens with different socio-demographic features have to be questioned with regard to their attitudes toward measures to improve animal welfare in sow husbandry. The selection of these groups can be based on the four

clusters of citizens with different attitudes toward sow husbandry described in Chapter 2. These clusters can be compared in the effects of measures to improve animal welfare in sow husbandry on their attitudes in order to test if socio-demographics have an effect on determining the most favorable measure. Combining the effects of these measures on citizens' attitudes toward sow husbandry of all four clusters will give results that are more representative for the Netherlands.

7.5 Implications

Interplay pig sector and citizens

This thesis has shown that the sector has to focus on citizens' attitudes, rather than on consumers' attitudes. Although citizens and consumers are the same person, the attitudes they have as citizens have in general a low effect on purchasing behavior as consumers (De Jonge and van Trijp, 2013; Harper and Henson, 2001; Verbeke et al., 2010). This means that many consumers still buy pig meat, even when they do not support sow husbandry as citizens. In the Netherlands, the pig sector tried to improve citizens' attitudes but this thesis (Chapter 2) shows that attitudes remain negative. This means that the pig sector has to use a different approach to positively affect citizens' attitudes. Until now the pig sector used an approach in which they focused on a single issue that was publicly debated, such as piglet mortality, and developed a measure to improve animal welfare in relation to that issue, in this case decreasing piglet mortality. These measures had to have a positive effect or only a limited negative effect on farm income. Otherwise, pig farmers would not implement these measures, even if there was an improvement of animal welfare (De Greef and Casabianca, 2009). In the development of these measures, citizens' attitudes were disregarded. The results of this thesis show that the improvement in animal welfare does not necessarily result in the improvement of citizens' attitudes (Chapter 6). This means that without including the effect of measures to improve animal welfare in sow husbandry on citizens' attitudes, the approach of the pig sector is doomed to fail. In order to make these measures successful, a more comprehensive approach has to be used that integrates the effects of these measures on animal welfare, farm income and citizens' attitudes. For the pig sector to know what these effects will be on citizens' attitudes, they first have to learn to understand citizens' attitudes. In order to understand citizens' attitudes, the pig sector has to know the underlying moral values. Chapter 4 showed that certain basic values are shared by citizens and conventional pig farmers, such as pigs being sentient and that pigs should be individually treated. These basic values fit in the first of three moral layers

mentioned by Cohen et al. (2010a); moral values shared by society. Other basic values differed between clusters of citizens and conventional pig farmers, such as the function of pigs is meat for humans and living conditions should meet natural demands. These basic values fit in the second layer of moral layers; moral values that are specific to an individual or group of people (Cohen, 2010a). That these moral values differ between citizens and conventional pig farmers is influenced by the context. The context determines how a person weighs their moral values against their personal values and interests (Cohen et al., 2009). In the context of sow husbandry, conventional pig farmers indicated to find constituents of naturalness unimportant, such as the possibility for pigs to go outside, while citizens found the same constituents highly important (Chapter 4). Pig farmers might have indicated to find these constituents unimportant because the context makes them think of the limited possibilities within their farm. In the current sow husbandry system it is difficult, if not impossible, to give pigs the possibility to go outside. Therefore, pig farmers consider other options to meet the natural requirements of pigs, such as increasing indoor surface per animal to improve freedom of movement. Because naturalness is connected to basic values in relation to sow husbandry, these basic values will be interpreted and weighed differently between citizens and conventional pig farmers. This different interpretation and weighing results in conflicting attitudes toward animal welfare (Te Velde et al., 2002). This means that when the pig sector believes they have improved animal welfare, citizens do not agree on this improvement. For example, with the introduction of the measure 'motherless rearing', the pig sector believed that animal welfare improved because piglet mortality decreased. However, citizens consider different aspects of naturalness than pig farmers, i.e., piglets being raised without a mother, which made them not support this measure. When the pig sector works from their own believes they are often completely beside the mark when it comes to improving citizens attitudes toward sow husbandry. This already starts with the focus of the pig sector on an issue of sow husbandry that is believed to raise citizens' concerns. For example, the current thesis was a response to concerns about piglet mortality. It was stated by the sector, the parliament and the government that citizens had negative attitudes toward piglet mortality because this issue appeared in the media multiple times. However, findings show that most citizens (64%) did not have an opinion about piglet mortality (Chapter 3). The pig sector might have misjudged citizens' attitudes with regard to piglet mortality and has no idea which attitudes and moral values are relevant for this particular issue (third layer of moral value of Cohen et al. (2010a)). Therefore, it is important that the pig sector learns to understand the underlying moral values of citizens. When these underlying moral values are understood, the sector can anticipate on issues that really matter to citizens.

The government and key players in the pig sector itself (e.g. retailers, meat companies) can play an important role in making the pig sector understand citizens' attitudes. For example, they can organize briefings, discussions and workshops. For briefings and discussions, various actors from the sector, including pig farmers, and citizens can be invited to share their ideas about sow husbandry and, most importantly, how they came to these ideas (underlying values). The selection of citizens that are best to invite can be selected based on the different clusters of citizens that are described in this thesis (Chapter 2). For example, when the pig sector wants to understand the negative attitudes toward sow husbandry of the biggest group of citizens, people from the cluster that included 40% of the respondents can be invited. Citizens from the smallest cluster (7% of respondents) have no negative attitudes toward sow husbandry, which means that inviting only people from that cluster for briefings and discussions will give no insight in negative citizens' attitudes toward sow husbandry. The clusters can also be used to select people to attend a workshop. In these workshops, citizens and pig farmers can learn about each other's attitudes and moral values toward sow husbandry by, for example, showing them different scenarios and discuss the different responses of these groups. The attitudes and moral values on which can be focused during the workshop can be selected based on this thesis (Chapter 2, 3, 4).

Because citizens' attitudes change over time (Chrispeels and Mandoli, 2003; Rollin, 2004) it is important that the pig sector stays informed about citizens' attitudes toward sow husbandry. Therefore, the government and key players in the pig sector can distribute a questionnaire to citizens on a regular basis (for example, every five years). This questionnaire can be based on the framework presented in Chapter 2. Based on the results of the questionnaire it is possible to determine how citizens' attitudes toward sow husbandry have changed through the years and what the main issues of concerns are.

With regard to specific issues of sow husbandry that, for example, are often debated or that arise because of a disease outbreak, the pig sector should arrange meetings with stakeholders of the pig sector, including pig farmers, and citizens. That way, the pig sector can learn from citizens which issues in particular raise citizens' concerns and citizens can participate in the conversation about measures that should be developed with regard to the specific issue. Citizens in those meetings can clarify for the sector which aspects are important for them with regard to the issue, so that the sector can include these aspects in the development of measures. The aspects that are important with regard to the specific issue can be selected from the framework presented in this thesis (Chapter 2). The selected aspects can be focused on during the meeting.

Communication

For the improvement of citizens' attitudes toward sow husbandry, good communication between the pig sector and citizens is essential. Kanis et al. (2003) state that citizens base their attitudes toward sow husbandry on information they receive. However, just after a lot of media attention given to piglet mortality, citizens indicated to have no opinion about piglet mortality (Chapter 3), possibly because they do not know what the percentage of piglet mortality within sow husbandry is. This means that citizens do not, by definition, have negative attitudes toward sow husbandry, which gives the pig sector more possibilities to influence citizens' attitudes by information provision. This information should not be too technical, because citizens are not that interested in technical information but rather in the feeling they have with sow husbandry (Backus and van der Schans, 2000). Therefore, it is important that pig farmers share their feelings, that find their basis in moral values, with citizens and explain to citizens why they take certain animal welfare measures. For example, with regard to piglet castration, pig farmers should communicate to citizens that they prefer not to castrate piglets for reasons of animal welfare and naturalness, but that they have to because of retailer requirements. The basis for this communication lies in the basic values that pig farmers share with citizens (Chapter 4). The shared basic values can contribute to improve the understanding between pig farmers and citizens. The other way around, pig farmers can learn from citizens that value various basic values differently (Chapter 4) in order to understand citizens' negative attitudes toward sow husbandry. Sharing feelings with citizens can best be done by first-hand information from the pig farmers and their farm. Pig farmers can share information, for example, by using webcams inside pig stables and release (live) footage on websites or through social media (Rutseart et al., 2014), or by the concept 'zichtstallen' (Stichting Varkens in Zicht, 2014) in which citizens are invited to visit one of the participating (breeding or growing) pig farms. By receiving this information, citizens can get a better understanding of what is done within sow husbandry and why it is done. Furthermore, these 'zichtstallen' give pig farmers the opportunity to get to know citizens and their attitudes. The aforementioned initiatives can be more promoted by the government and the pig sector in order to stimulate citizens to watch footage and visit these farms and to stimulate pig farmers to participate. To extra stimulate pig farmers, the government can stimulate and facilitate those initiatives.

Future research

The measures to improve animal welfare in sow husbandry had a small effect on citizens' attitudes. To find out whether there are measures with a stronger effect on citizens' attitudes, further research is necessary. For a stronger effect on these attitudes it might be necessary to combine two or more measures that can be implemented in an existing sow farm or to look at measures that involve a newly designed sow farm. To determine the most efficient measure in terms of their effects on animal welfare, farm income and citizens' attitudes, the simulation model described in Chapter 6 can be used. In order to verify the attitudes module of this model, it is recommended to verify results similar to the approach described in paragraph 7.4. For verification a group of citizens representative for the Netherlands has to be questioned.

An environment module can be added to the model described in Chapter 6 to estimate the effect of measures to improve animal welfare in sow husbandry on the environment.

7.6 Main conclusions

This thesis provided information on attitudes and basic values related to sow husbandry of different stakeholders, i.e., citizens, pig farmers (conventional and organic), pig husbandry advisors and pig veterinarians. Furthermore, this thesis has shown that it is essential for the pig sector to use a more comprehensive approach that integrates the effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes, in order to make these measures successful.

From this thesis, the following main conclusions can be drawn:

- Most Dutch citizens have negative attitudes toward sow husbandry with respect to both animals, humans and the environment (Chapter 2).
- Based on attitudes toward sow husbandry with respect to animals, humans and the environment, citizens could be divided into four separate clusters (Chapter 2).
- Stakeholders of sow husbandry can be divided into three distinctive groups with regard to their attitudes toward sow husbandry: 1) citizens and organic pig farmers with negative attitudes toward sow husbandry with respect to all aspects mentioned in the framework, 2) conventional pig farmers and pig yard entrants with only negative attitudes toward sow husbandry with respect to aspects related to income, and 3) pig veterinarians with negative attitudes toward sow husbandry with respect to specific aspects, that were sometimes similar to the first group, such as euthanasia, and sometimes similar to the second group, such as farm income (Chapter 3).

- For both citizens and conventional pig farmers, there was a low correlation between the their basic values and the degree of extra attention they deemed necessary for aspects of sow husbandry related to animals, humans and the environment (Chapter 4).
- Measures to improve animal welfare in sow husbandry do not have the same relative impacts on animal welfare, farm income (Chapter 5) and citizens' attitudes (Chapter 6).
- Including the effects of animal welfare measures on citizens' attitudes, next to the effects on animal welfare and farm income (Chapter 6) gives different results on the most efficient measure compared to only including effects on animal welfare and farm income (Chapter 5).
- Measures to lower piglet mortality were most cost-efficient in terms of their effects on animal welfare and farm income, compared to measures to decrease tail biting and improve indoor housing of gestating sows (Chapter 5).
- The measure in which groups of gestating sows are increased and provided with straw and daylight was the most efficient one in terms of its effects on animal welfare, farm income and citizens' attitudes (Chapter 6).
- The pig sector needs to understand the basic values and attitudes toward sow husbandry of citizens to be able to improve citizens' attitudes toward sow husbandry through animal welfare improving measures (Chapter 7).

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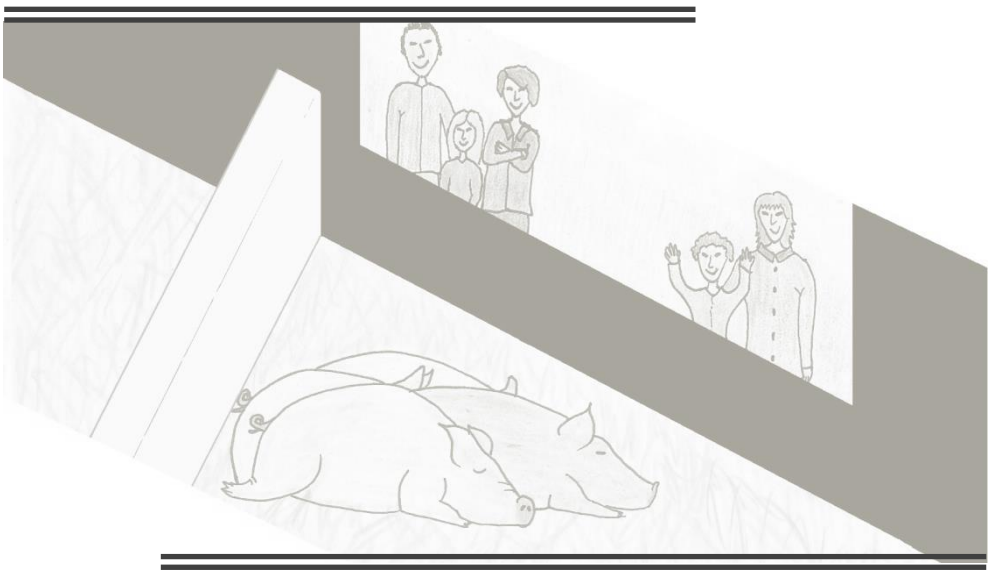

Summary

In the last decades, societal concerns about intensive animal husbandry have increased. This resulted in an increasing number of public debates regarding animal welfare in intensive animal husbandry systems. One of the animal husbandry systems in the Netherlands that is struggling with societal concerns is sow husbandry. Sow husbandry has tried to respond to citizens' concerns by introducing new measures to improve animal welfare. However, after introduction of these measures, citizens' concerns remained, which is an indication that measures on animal welfare do not have the desired effect on citizens' attitudes. To understand why animal welfare measures fail to improve citizens' attitudes it is essential to identify the effect of these measures on citizens' attitudes, next to their effect on animal welfare and farm income. The effect on farm income has to be included because the economic effects of animal welfare measures are one of the main drivers for pig farmers. The main objective of this thesis was to estimate the effects of measures to improve animal welfare in sow husbandry in the Netherlands on animal welfare, farm income and citizens' attitudes. To achieve this objective several steps were taken in the different chapters of this thesis.

Chapter 2 presents a conceptual framework which includes different aspects related to the entities 'animals', 'humans' and 'environment' that play a role in attitudes toward sow husbandry. The selection of these aspects was based on literature and consultancies with experts. This framework was the basis of the remainder of the thesis. Based on this framework a questionnaire was developed to get insight in the attitudes of citizens toward sow husbandry. In the questionnaire, respondents could indicate their attitudes in additional care (AC) levels, i.e., the degree of extra attention necessary compared to the current situation, for each of the aspect from the framework. Results show that the AC levels were on average 3.3 or higher on a five-point scale for all defined aspects. This indicates that all these aspects are important in citizens' attitudes toward sow husbandry. The highest AC levels were assigned to the following aspects: the number of animals kept per square meter, the possibility for animals to go outside, food safety risks, public health risks and environmental waste. Based on AC levels, four clusters of citizens could be formed. Only the smallest cluster (no-AC cluster with 7.1% of the respondents) showed no or slightly negative attitudes toward pig husbandry. The other three clusters showed negative attitudes toward pig husbandry with respect to all defined aspects, indicating that a vast majority of Dutch citizens has negative attitudes toward sow husbandry. The second smallest cluster (high-AC cluster with 14% of the respondents) showed the most extreme negative attitudes toward sow husbandry with AC-levels above 4. The two biggest clusters

showed slightly negative attitudes (moderate-AC cluster with 38.8% of the respondents; AC levels between 3.0 and 3.8) or strong negative attitudes (high-AC cluster with 40.1% of the respondents; AC levels between 3.2 and 4.5) toward sow husbandry. The clusters differed in socio-demographic features which were in most cases not distinctive in the two biggest clusters, but were distinctive in the two smallest clusters. Respondents that often ate pig meat, were raised in a small villages or visited a pig farm at least once had a higher chance to be in the cluster without negative attitudes toward sow husbandry compared to the other clusters. Respondents older than 55 years, being a little religious (i.e., believing there is 'something') or having lower education had a higher probability to be in the cluster with the most extreme negative attitudes towards sow husbandry compared to the other clusters. Based on these findings it was stated that socio-demographics can be indicative for citizens' attitudes toward sow husbandry.

In Chapter 3 the attitudes toward sow husbandry of citizens were compared with the attitudes of four other important stakeholders for sow husbandry; conventional pig farmers, organic pig farmers, pig husbandry advisors and pig veterinarians. The results on attitudes toward sow husbandry of citizens were obtained from Chapter 2. The attitudes of the other stakeholders were determined based on the same questionnaire that citizens received. Furthermore, it was determined whether stakeholders found issues related to sow husbandry that came to the fore in public debates, such as piglet mortality and indoor pig housing, acceptable or not. Based on the results on attitudes toward sow husbandry and the acceptability of issues related to sow husbandry, the studied stakeholders could be divided into three distinctive groups. The group of citizens and organic pig farmers showed negative attitudes toward sow husbandry with respect to all defined aspects and found several issues of sow husbandry, such as interventions without sedation and indoor housing, unacceptable. The group of conventional pig farmers and pig husbandry advisors showed only negative attitudes toward sow husbandry in respect to economic aspects and found all presented issues acceptable. The group of pig veterinarians showed negative attitudes to specific aspects of pig husbandry, such as euthanasia and farm income, and found specific issues of sow husbandry unacceptable, such as the use of antibiotics and castration. Result of this chapter on attitudes toward sow husbandry of conventional pig farmers and citizens were used in Chapter 4 to compare them with basic values related to sow husbandry of these stakeholders.

Chapter 4 presents an extension of the theoretical framework presented in Chapter 2. The extension consists of basic values that underlie attitudes toward sow husbandry. A questionnaire was developed to get insight in the basic values of citizens and conventional pig farmers. It was studied whether basic values can predict the attitudes toward sow

husbandry of these groups. Furthermore, the usefulness of basic values in closing the gap in attitudes toward sow husbandry between citizens and pig farmers was studied. In the analyses the collected data on basic values were combined with the collected data on attitudes toward sow husbandry of citizens and conventional pig farmers (Chapter 2 and 3). Results show that basic values are not one-on-one related to the attitudes that these stakeholders have toward sow husbandry. Most of the basic values were shared by conventional pig farmers and citizens as one group. However, when comparing the various basic values of the four clusters of citizens that show different attitudes toward sow husbandry (Chapter 2) with conventional pig farmers, there were some differences. The two clusters with the most negative attitudes toward sow husbandry (the high-AC cluster and the max-AC cluster) did not agree on the valuation of basic values with convetnional pig farmers. The other two clusters (moderate-AC cluster slightly negative attitudes toward sow husbandry and no-AC cluster with no negative attitudes toward sow husbandry), did agree on the valuation of most of the basic values with conventional pig farmers. The moderate-AC cluster shared the basic value 'living condition should be natural' with the high-AC cluster and the max-AC cluster. Weighing this basic value is based on the interpretation of naturalness, which was found to be different between citizens and conventional pig farmers. With many basic values shared, pig farmers can learn to understand the interpretation and weighing of basic values by citizens of the moderate-AC cluster. With this understanding they will be better able to understand the moral reasoning of the high-AC cluster and the max-AC cluster. This understanding can be used in the development of new systems and measures to improve animal welfare within sow husbandry and in the communication between pig farmers and citizens.

Chapter 5 focused on the effect of measures to improve animal welfare in sow husbandry on animal welfare and farm income. By including these effects, the economic interests of pig farmers are taken into account, as well as the interest of citizens in animal welfare. Three issues of sow husbandry were selected to focus on: piglet mortality, tail biting and indoor housing. For each of these issues, four measures were defined to improve animal welfare that can be implemented in an existing sow farm. A reference sow farm, representative for the Netherlands, was described in which the measures could be implemented. The effects of the defined measures on animal welfare and farm income were estimated with a simulation model, which was called the animal-welfare-economics (WelEc) model, consisting of an economic and an animal welfare module. The output of the two modules provided an estimation of the net farm income and an animal welfare score. With a cost-effectiveness ratio, i.e., the change in net farm income relative to a default situation divided by the change in animal welfare score relative to the default situation, the

different measures for animal welfare improvement were compared. The measures related to piglet mortality were the only measures with a positive effect on net farm income and had the highest cost-effectiveness ratio compared to the other measures. The measures in which gestating sows get the possibility to free range outside and the measure in which the groups of gestating sows are increased and in which the sows receive straw and daylight, had the highest effect on animal welfare compared to the other defined measures. Results in this chapter show that a positive effect of measures to improve animal welfare in sow husbandry on animal welfare does not necessarily result in a negative effect on net farm income. This means that it is important to evaluate the effect of measures to improve animal welfare in sow husbandry on both animal welfare and farm income, before deciding which measure is best to implement. The reference farm and measures that are described in this chapter were used in Chapter 6, which describes an extension of the WelEc model with an attitude module. With this extended model, an integrated assessment of the effects of measures to improve animal welfare in sow husbandry on citizens' attitudes, animal welfare and farm income could be made. The comparison was done by means of Data Envelopment Analysis (DEA). The efficiencies calculated by DEA showed that the most efficient measure was the measure that included straw provision, daylight and increased group sizes for gestating sows. The measures related to piglet mortality were the only measures with a positive effect net farm income. The relatively low effects of the measures related to piglet mortality on animal welfare and citizens' attitudes explains why these measures were not efficient. This study has shown that a positive effect of a measure on animal welfare did not necessarily lead to a similar relative improvement of citizens' attitudes or a deterioration of farm income. This indicates that it is essential to use a more comprehensive approach for evaluating animal welfare measures.

Chapter 7 synthesized the results of the different chapters, discussed the use of interdisciplinary approaches in this thesis and discussed implications for the pig sector and future research. As shown in this thesis, the use of an interdisciplinary approach that includes citizens' attitudes, next to animal welfare and farm income, is essential for the pig sector. With the developed framework in this thesis (Chapter 2) it was possible to get a more comprehensive idea about attitudes toward sow husbandry of different stakeholders, because aspects related to both animals, humans and the environment were included. By including the effects of measures to improve animal welfare in sow husbandry on citizens' attitudes, next to the effects on animal welfare and farm income, made it possible to understand why these measures sometimes fail in improving citizens' attitudes. A limited verification study was carried out among Dutch citizens to verify the made estimations with regard to the effect of measures to improve animal welfare in sow husbandry on citizens'

attitudes (Chapter 6). The results of this study showed that citizens' attitudes improve when any of the proposed measures will be implemented. However, results also suggested that it is difficult to estimate the effect of the defined measures on citizens' attitudes. For the pig sector to improve citizens' attitudes toward sow husbandry, Chapter 7 suggests that the sector first has to understand citizens' moral reasoning behind these attitudes. Several tools are provided for the sector to learn to understand this moral reasoning and citizens' attitudes toward sow husbandry.

This thesis provided information on attitudes and basic values related to sow husbandry of different stakeholders, i.e., citizens, pig farmers (conventional and organic), pig husbandry advisors and pig veterinarians. Furthermore, this thesis has shown that it is essential for the pig sector to use a more comprehensive approach that integrates the effects of measures to improve animal welfare in sow husbandry on animal welfare, farm income and citizens' attitudes, in order to make these measures successful.

From this thesis, the following main conclusions can be drawn:

- Most Dutch citizens have negative attitudes toward sow husbandry with respect to both animals, humans and the environment (Chapter 2).
- Based on attitudes toward sow husbandry with respect to animals, humans and the environment, citizens could be divided into four separate clusters (Chapter 2).
- Stakeholders of sow husbandry can be divided into three distinctive groups with regard to their attitudes toward sow husbandry: 1) citizens and organic pig farmers with negative attitudes toward sow husbandry with respect to all aspects mentioned in the framework, 2) conventional pig farmers and pig yard entrants with only negative attitudes toward sow husbandry with respect to aspects related to income, and 3) pig veterinarians with negative attitudes toward sow husbandry with respect to specific aspects, that were sometimes similar to the first group, such as euthanasia, and sometimes similar to the second group, such as farm income (Chapter 3).
- For both citizens and conventional pig farmers, there was a low correlation between the their basic values and the degree of extra attention they deemed necessary for aspects of sow husbandry related to animals, humans and the environment (Chapter 4).
- Measures to improve animal welfare in sow husbandry do not have the same relative impacts on animal welfare, farm income (Chapter 5) and citizens' attitudes (Chapter 6).
- Including the effects of animal welfare measures on citizens' attitudes (Chapter 6) gives different results on the most efficient measure compared to only including effects on animal welfare and farm income (Chapter 5).

- Measures to lower piglet mortality were most cost-efficient in terms of their effects on animal welfare and farm income, compared to measures to decrease tail biting and improve indoor housing of gestating sows (Chapter 5).
- The measure in which groups of gestating sows are increased and provided with straw and daylight was the most efficient one in terms of its effects on animal welfare, farm income and citizens' attitudes (Chapter 6).
- The pig sector needs to understand the basic values and attitudes toward sow husbandry of citizens to be able to improve citizens' attitudes toward sow husbandry through animal welfare improving measures (Chapter 7).

Samenvatting

In de laatste decennia zijn maatschappelijke zorgen over de intensieve veehouderij toegenomen. Dit heeft geresulteerd in een toenemend aantal publieke debatten over dierenwelzijn in intensieve veehouderijsystemen. Een van de veehouderijsystemen in Nederland die worstelt met maatschappelijke zorgen is de zeugenhouderij. De zeugenhouderij heeft geprobeerd te reageren op de zorgen van burgers door nieuwe maatregelen te introduceren om het dierenwelzijn te verbeteren. Echter, de zorgen van burgers bleven bestaan nadat deze maatregelen geïntroduceerd waren. Dit geeft aan dat dierenwelzijnsmaatregelen niet het gewenste effect hebben op attitudes van burgers. Om te begrijpen waarom dierenwelzijnsmaatregelen er niet in slagen om attitudes van burgers te verbeteren is het noodzakelijk om het effect van deze maatregelen op burgers hun attitudes te bepalen, naast het effect op dierenwelzijn en bedrijfsinkomen. Het effect op bedrijfsinkomen moet worden meegenomen omdat de economische effecten van dierenwelzijnsmaatregelen een van de belangrijkste drijfveren is voor varkenshouders. De belangrijkste doelstelling van dit proefschrift was het schatten van de effecten van maatregelen om dierenwelzijn in de zeugenhouderij in Nederland te verbeteren op dierenwelzijn, bedrijfsinkomen en attitudes van burgers. Om dit doel te bereiken zijn verschillende stappen genomen in de verschillende hoofdstukken van dit proefschrift.

Hoofdstuk 2 presenteert een conceptueel raamwerk met verschillende aspecten gerelateerd aan de entiteiten ‘dieren’, ‘mensen’ en ‘omgeving’ die een rol spelen in attitudes richting de zeugenhouderij. Deze aspecten zijn geselecteerd op basis van literatuur en advies van experts. Het raamwerk was de basis voor de rest van het proefschrift. Aan de hand van dit raamwerk is een enquête ontwikkeld om inzicht te krijgen in attitudes van burgers richting de zeugenhouderij. In deze enquête konden burgers hun attitudes weergeven in de vorm van extra zorg (AC; additional care) niveaus, d.w.z. de mate van extra zorg die nodig geacht wordt vergeleken met de huidige situatie, voor ieder aspect uit het raamwerk. Resultaten laten zien dat de AC niveaus gemiddeld 3,3 of hoger waren op een schaal van vijf voor alle aspecten. Dit geeft weer dat al deze aspecten belangrijk zijn in attitudes van burgers richting de zeugenhouderij. De hoogste AC niveaus waren toegewezen aan de volgende aspecten: het aantal gehouden dieren per vierkante meter, de mogelijkheid voor dieren om naar buiten te gaan, voedselveiligheidsrisico’s, volksgezondheidsrisico’s en milieuvervuiling. Op basis van AC niveaus konden vier clusters van burgers worden gevormd. Alleen het kleinste cluster (no-AC cluster met 7,1% van de respondenten) had geen of nauwelijks negatieve attitudes richting de zeugenhouderij. De andere drie clusters hadden negatieve attitudes richting de zeugenhouderij met betrekking

tot alle genoemde aspecten. Dit geeft aan dat de grote meerderheid van de Nederlandse bevolking negatieve attitudes richting de zeugenhouderij heeft. Het op een na kleinste cluster (high-AC cluster met 14% van de respondenten) had de meest negatieve attitudes richting de zeugenhouderij met AC niveaus boven 4. De twee grootste clusters hadden licht negatieve attitudes (high-AC cluster met 38,8% van de respondenten; AC niveaus tussen 3.0 en 3.8) of sterk negatieve attitudes (high-AC cluster met 40,1% van de respondenten; AC niveaus tussen 3.2 en 4.5) richting de zeugenhouderij. De clusters verschilden in socio-demografische kenmerken. Deze kenmerken waren vaak niet onderscheidend in de twee grootste clusters, maar waren wel onderscheidend in de twee kleinste clusters. Respondenten die vaak varkensvlees aten, waren opgegroeid in een klein dorp of tenminste eenmaal een varkenshouderij hadden bezocht hadden een grotere kans om in het cluster zonder negatieve attitudes richting de zeugenhouderij te zitten dan in de andere drie clusters. Respondenten ouder dan 55 jaar, een beetje religieus (d.w.z. geloven dat er 'iets' is) of die met een lagere opleiding hadden een grotere kans om in het cluster met de meest negatieve attitudes richting de zeugenhouderij te zitten dan in de andere drie clusters. Op basis van deze resultaten werd gesteld dat socio-demografische kenmerken indicatief kunnen zijn voor attitudes van burgers richting de zeugenhouderij.

In hoofdstuk 3 zijn attitudes richting de zeugenhouderij van burgers vergeleken met deze attitudes van vier andere belangrijke stakeholders; conventionele varkenshouders, biologische varkenshouders, varkensadviseurs en varkensdierenartsen. De resultaten van attitudes van burgers richting de zeugenhouderij zijn overgenomen van hoofdstuk 2. De attitudes van de andere stakeholders werden bepaald aan de hand van dezelfde enquête als bij de burgers. Daarnaast is bepaald of stakeholders verschillende issues van de zeugenhouderij die werden besproken in publieke debatten, zoals biggensterfte en binnenhuisvesting, acceptabel vonden of niet. Aan de hand van de resultaten m.b.t. attitudes richting de zeugenhouderij en acceptatie van issues van de zeugenhouderij konden de stakeholders in drie onderscheidende groepen worden ingedeeld. De groep van burgers en biologische varkenshouders hadden negatieve attitudes richting de zeugenhouderij met betrekking tot alle genoemde aspecten en vonden meerdere issues van de zeugenhouderij, zoals ingrepen zonder verdoving en binnenhuisvesting, onacceptabel. De groep van intensieve varkenshouders en varkensadviseurs hadden alleen negatieve attitudes richting de zeugenhouderij met betrekking tot economische aspecten en vonden alle genoemde issues acceptabel. De groep varkensdierenartsen had negatieve attitudes richting de zeugenhouderij met betrekking tot specifieke aspecten, zoals euthanasie en bedrijfsinkomen, en vond specifieke issues van de zeugenhouderij onacceptabel, zoals het gebruik van antibiotica en castratie. Resultaten uit dit hoofdstuk

van attitudes richting de zeugenhouderij van intensieve varkenshouders en burgers zijn gebruikt in Hoofdstuk 4 om deze te vergelijken met basiswaarden gerelateerd aan de zeugenhouderij van deze stakeholders.

Hoofdstuk 4 presenteert een uitbreiding van het raamwerk beschreven in Hoofdstuk 2. Deze uitbreiding bestaat uit basiswaarden die ten grondslag liggen aan attitudes richting de zeugenhouderij. Er was een enquête ontwikkeld om inzicht te krijgen in deze basiswaarden van intensieve varkenshouders en burgers. Er is onderzocht of basiswaarden de attitudes van deze stakeholders richting de zeugenhouderij kunnen voorspellen. Daarnaast is de bruikbaarheid van basiswaarden in het dichten van de kloof in attitudes richting de zeugenhouderij tussen burgers en intensieve varkenshouders onderzocht. In de analyses is de verzamelde data van de basiswaarden gekoppeld aan de verzamelde data van de attitudes richting de zeugenhouderij van burgers en intensieve varkenshouders (Hoofdstuk 2 en 3). Resultaten laten zien dat basiswaarden niet één-op-één gerelateerd zijn aan attitudes van deze stakeholders richting de zeugenhouderij. De meeste basiswaarden werden gedeeld door intensieve varkenshouders en burgers als een enkele groep. Echter, bij het vergelijken van de basiswaarden van de verschillende clusters burgers met verschillende attitudes richting de zeugenhouderij (Hoofdstuk 2) en intensieve varkens-houders, zijn er verschillen gevonden. De twee clusters met de meeste negatieve attitudes richting de zeugenhouderij (high-AC cluster en max-AC cluster) waren het niet eens met de waarde die intensieve varkens hadden toegewezen aan de basiswaarden. De andere twee clusters (moderate-AC cluster met licht negatieve attitudes richting de zeugenhouderij en no-AC cluster met geen negatieve attitudes richting de zeugenhouderij) waren het grotendeels eens met de waarden die intensieve varkenshouders hadden toegewezen aan de basiswaarden. Het moderate-AC cluster deelde de basiswaarde 'leefomstandigheden moeten natuurlijk zijn' met het high-AC cluster en het max-AC cluster. De weging van deze basiswaarden is gebaseerd op de interpretatie van natuurlijkheid. Resultaten laten zien dat deze interpretatie verschilt tussen burgers en intensieve varkenshouders. Doordat ze veel basiswaarden delen, kunnen intensieve varkenshouders van burgers in het moderate-AC cluster leren begrijpen hoe burgers basiswaarden interpreteren en wegen. Wanneer ze dit begrijpen kunnen ze de morele redenering van het high-AC cluster en het max-AC cluster beter begrijpen. Dit kunnen ze gebruiken in de ontwikkeling van nieuwe systemen en maatregelen voor het verbeteren van dierenwelzijn in de zeugenhouderij en in de communicatie tussen varkenshouders en burgers.

Hoofdstuk 5 richtte zich op het effect van maatregelen voor het verbeteren van dierenwelzijn in de zeugenhouderij op dierenwelzijn en bedrijfsinkomen. Door deze effecten mee te nemen worden zowel de economische interesses van varkenshouders als

de interesses van burgers in dierenwelzijn erbij betrokken. Drie issues in relatie tot de zeugenhouderij waren geselecteerd als focus: biggensterfte, staartbijten en binnenhuisvesting. Voor elk van deze issues zijn vier maatregelen gedefinieerd die het dierenwelzijn verbeteren en die toepasbaar zijn in een bestaande zeugenhouderij. Een referentie zeugenhouderij, representatief voor Nederland, is beschreven waarin deze maatregelen geïmplementeerd kunnen worden. De effecten van de gedefinieerde maatregelen op dierenwelzijn en bedrijfsinkomen zijn geschat met een simulatiemodel, genoemd het animal-welfare-economics (WelEc) model, bestaande uit een economisch en dierenwelzijn module. De uitkomsten van deze modules gaven een schatting van het netto bedrijfsinkomen en een dierenwelzijnsscore. Met een kosten-effectiviteitsratio, d.w.z. de toename/afname in netto bedrijfsinkomen ten opzichte van de standaard situatie gedeeld door de toename in dierenwelzijnsscore ten opzichte van de standaard situatie, zijn de gedefinieerde maatregelen met elkaar vergeleken. De maatregelen in relatie tot biggensterfte waren de enige maatregelen met een positief effect op netto bedrijfsinkomen en hadden de hoogste kosten-effectiviteitsratio's vergeleken met de andere maatregelen. De maatregelen waarin drachtige zeugen een vrije uitloop krijgen en de maatregel waarin de groepen drachtige zeugen worden vergroot en stro en daglicht krijgen, hadden het grootste effect op dierenwelzijn vergeleken met de andere maatregelen. Resultaten in dit hoofdstuk laten zien dat een positief effect van maatregelen om dierenwelzijn in de zeugenhouderij te verbeteren op dierenwelzijn niet hoeft te beteken dat deze maatregelen een negatief effect hebben op netto bedrijfsinkomen. Dit betekent dat het belangrijk is om het effect van maatregelen om dierenwelzijn in de zeugenhouderij te verbeteren op zowel dierenwelzijn als op netto bedrijfsinkomen te evalueren, voordat er besloten wordt welke maatregelen het best geïmplementeerd kan worden. De referentie zeugenhouderij en de maatregelen die beschreven zijn in dit hoofdstuk zijn meegenomen in Hoofdstuk 6, waarin het WelEc model is uitgebreid met een attitude module. Met deze uitbreiding was het mogelijk om een schatting te maken van de gecombineerde effecten van maatregelen om dierenwelzijn in de zeugenhouderij te verbeteren op attitudes van burgers, dierenwelzijn en bedrijfsinkomen. Om de gedefinieerde maatregelen met elkaar te vergelijken is Data Envelopment Analysis (DEA) gebruikt. De efficiënties die berekend zijn met DEA laten zien dat de meest efficiënte maatregel de maatregel was waarin groepen drachtige zeugen worden vergroot en stro en daglicht krijgen. De maatregelen in relatie tot biggensterfte waren de enige maatregelen met een positief effect op bedrijfsinkomen. Het relatief lage effect van deze maatregelen op dierenwelzijn en attitudes van burgers verklaart waarom deze maatregelen niet efficiënt waren. Deze studie heeft laten zien dat een positief effect van een maatregel op

dierenwelzijn niet hoeft te resulteren in een relatief gelijk effect op attitudes van burgers of een negatief effect op bedrijfsinkomen. Dit geeft aan dat het essentieel is om een meer uitgebreide benadering te gebruiken in de evaluatie van dierenwelzijnsmaatregelen.

In Hoofdstuk 7 zijn de resultaten van de verschillende hoofstukken gesynthetiseerd, het gebruik van een interdisciplinaire benadering bediscussieerd en de implicaties voor de varkenssector en toekomstig onderzoek besproken. Zoals dit proefschrift laat zien, is het essentieel voor de varkenssector om een interdisciplinaire benadering te gebruiken waarin, naast dierenwelzijn en bedrijfsinkomen, de attitudes van burgers worden betrokken. Met het raamwerk beschreven in dit proefschrift (Hoofdstuk 2) was het mogelijk om een meer compleet beeld te krijgen van attitudes richting de zeugenhouderij van verschillende stakeholders, omdat aspecten gerelateerd aan zowel dieren, mensen als de omgeving zijn meegenomen. Door het effect van maatregelen om dierenwelzijn in de zeugenhouderij te verbeteren op attitudes van burgers, naast het effect op dierenwelzijn en bedrijfsinkomen, mee te nemen was het mogelijk om te achterhalen waarom sommige van deze maatregelen er niet in slagen om attitudes van burgers te verbeteren. Een beperkte verificatie studie was uitgevoerd onder Nederlandse burgers om de schattingen gemaakt voor het effect van maatregelen om dierenwelzijn in de zeugenhouderij te verbeteren op de attitudes van burgers (Hoofdstuk 6) te verifiëren. De resultaten van deze studie laten zien dat de attitudes van burgers zullen verbeteren bij de introductie van elk van de gedefinieerde maatregelen. Echter, resultaten suggereerden ook dat het moeilijk is om het effect van de gedefinieerde maatregelen op attitudes van burgers te schatten. Hoofdstuk 7 geeft aan dat de sector eerst de morele redenering achter deze attitudes moet begrijpen voordat zij de attitudes van burgers richting de zeugenhouderij kan verbeteren. Verschillende handvatten worden in dit hoofdstuk toegereikt voor de sector om deze morele redenering te leren begrijpen.

Dit proefschrift heeft inzicht gegeven in attitudes en basiswaarden in relatie tot de zeugenhouderij van verschillende stakeholders, namelijk, burgers, varkenshouders (intensief en biologisch), varkensadviseurs en varkensdierenartsen. Daarnaast heeft dit proefschrift laten zien dat het essentieel voor de varkenssector is om een meer uitgebreide benadering te gebruiken, waarin de effecten van maatregelen om dierenwelzijn in de zeugenhouderij op dierenwelzijn, bedrijfsinkomen en attitudes van burgers worden geïntegreerd, om maatregelen succesvol te maken.

Uit dit proefschrift kunnen de volgende conclusies worden getrokken:

- De meeste Nederlandse burgers hebben negatieve attitudes richting de zeugenhouderij ten opzichte van dieren, mensen en de omgeving (Hoofdstuk 2).

- Aan de hand van attitudes richting de zeugenhouderij ten opzichte van dieren, mensen en de omgeving, kunnen burgers in vier onderscheidende clusters worden ingedeeld (Hoofdstuk 2).
- Stakeholders van de zeugenhouderij kunnen in drie onderscheidende groepen worden ingedeeld met betrekking tot hun attitudes richting de zeugenhouderij: 1) burgers en biologische varkenshouders met negatieve attitudes richting de zeugenhouderij met betrekking tot alle aspecten genoemd in het raamwerk, 2) intensieve varkenshouders en varkensadviseurs met alleen negatieve attitudes richting de zeugenhouderij met betrekking tot aspecten gerelateerd aan inkomen, en 3) varkensdierenartsen met negatieve attitudes richting de zeugenhouderij met betrekking tot specifieke aspecten, welke soms gelijk waren aan de eerste groep, zoals euthanasie, en soms gelijk waren aan de tweede groep, zoals bedrijfsinkomen (Hoofdstuk 3).
- Voor zowel burgers als voor intensieve varkenshouders was er een lage correlatie tussen hun basiswaarden en de mate van extra zorg dat ze nodig achtten voor aspecten van de zeugenhouderij gerelateerd aan dieren, mensen en de omgeving (Hoofdstuk 4).
- Maatregelen om dierenwelzijn in de zeugenhouderij te verbeteren hebben niet dezelfde relatieve impact op dierenwelzijn, bedrijfsinkomen (Hoofdstuk 5) en attitudes van burgers (Hoofdstuk 6).
- Het toevoegen van het effect van dierenwelzijnsmaatregelen op attitudes van burgers (Hoofdstuk 6) geeft andere resultaten met betrekking tot de meest efficiënte maatregel dan wanneer alleen de effecten op dierenwelzijn en bedrijfsinkomen worden meegenomen (Hoofdstuk 5).
- Maatregelen om biggensterfte te verlagen waren het meest kosteneffectief in termen van hun effect op dierenwelzijn en bedrijfsinkomen, vergeleken met maatregelen om staartbijten te verminderen en het verbeteren van binnenhuisvesting van drachtige zeugen (Hoofdstuk 5).
- De maatregel waarin groepen drachtige zeugen worden vergroot en stro en daglicht krijgen was het meest efficiënt in termen van het effect op dierenwelzijn, bedrijfsinkomen en attitudes van burgers (Hoofdstuk 6).
- Het is nodig voor de varkenssector om de basiswaarden en attitudes richting de zeugenhouderij van burgers te begrijpen om de attitudes van burgers richting de zeugenhouderij te kunnen verbeteren aan de hand van dierenwelzijnsmaatregelen (Hoofdstuk 7).

About the author

Tamara Bergstra was born in Heerenveen, the Netherlands, on 4 December 1983. In 2007 she obtained a honours BSc degree in Animal Management from Van Hall Institute in Leeuwarden, the Netherlands. During her BSc, Tamara studied the behavior of monkeys, piglets and sharks and she fulfilled policy and communication activities for the Society for the protection of animals. In 2010, Tamara obtained a MSc degree in Animal Science from Wageningen University, the Netherlands. During her MSc, she specialized in ethology and adaptation physiology. Her minor thesis was about polymorphism of chicken natural auto-antibodies and her major thesis was about separation anxiety in dogs. For both theses, she wrote a scientific paper of which the one related to the minor thesis was published in a scientific journal. During her MSc, Tamara had several student/research-assistant jobs. Twice she supervised groups of students during the course 'behaviour and environment' at Wageningen University, where students had to study the behavior of zoo animals (2009 and 2010). Furthermore, she was student-assistant in a PhD project on satiety in pigs, where she measured pig behavior (2010). Two times she was research-assistant for a literature study on animals on the negative- and positive list for mammals of the 'gezondheids- en welzijnswet voor dieren' (law for animal health and welfare; 2009 and 2010). Later on she helped deciding which animals of this list are suitable to keep as a pet (2013).

In August 2010, Tamara started her PhD at the Business Economics chair group of Wageningen University, where she studied attitudes toward sow husbandry and the effect of measures to improve animal welfare in sow husbandry on these attitudes. This project arose from citizens' concerns about pig husbandry and the pig sector being interested in how these concerns can be reduced. During her PhD, Tamara followed an education program at the Wageningen School of Social Sciences (WASS). In 2013, she received a WASS Junior Grant and a subsidy from Stichting LEB-fonds for collaborative work and an international conference in Australia.

List of publications

Refereed scientific journals

- Bergstra, T.J., K. Smeets, M.G.B. Nieuwland and H.K. Parmentier (2010) In vivo and in vitro post-translational polymorphism of chicken natural auto-antibodies, Developmental and Comparative Immonology, 34(8):821-827.
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Education certificate

Name of the learning activity	Department/Institute*	Year	ECTS**
Project related competences			
Research proposal	BEC, WUR	2011	4
'Framework to predict why concerns about animal production exist'	UFAW International Symposium, Portsmouth, United Kingdom		1
'Societal concerns about Dutch pig husbandry'	Minding Animal Conference, Utrecht, the Netherlands	2012	1
'Combining societal concerns about pig husbandry, economics and animal welfare'	WIAS Science Day, Wageningen, the Netherlands	2012	0.3
'Differences in concerns about pig husbandry between stakeholder groups'	WIAS Science Day, Wageningen, the Netherlands	2012	0.3
'Concerns of different stakeholder groups about pig husbandry'	EAAP Annual Meeting, Nantes, France	2013	1
'Attitudes of citizens and conventional pig farmers about pig husbandry in the Netherlands'	APSA, Manipulating pig production, Melbourne, Australia	2013	1
General research related competences			
Research methodology I: From topic to proposal	WASS	2010	4
Theoretical models and empirical measurement of the external cost of pesticides	BEC, WUR	2010	1.5
Animal & nature ethics	UU	2010	7.5

WASS introduction course	WASS	2011	0.75
Economic theory and concepts for the veterinary sciences	UU	2011	1.5
Applied economic modelling for the veterinary sciences	UU	2012	2
Presentation at WASS PhD Day	WASS	2012	1
Workshop animal health economics	Aarhus University	2012	1
Summer school Dynamic efficiency and productivity analysis	WASS	2013	3
PhD meetings Business Economics	BEC, WUR	2010-2014	4
Career related competences/personal development			
Scientific writing	WASS	2011	1.8
Mobilising your scientific network	WGS	2012	1
Assist computer lab Food safety economics	BEC, WUR	2012	0.5
Instruct MSc Student	ASG, WUR	2012	0.5
Total			**38.65**

* BEC: Business Economics, WUR: Wageningen University, UFAW: Universities Federation for Animal Welfare, WIAS: Wageningen Institute of Animal Sciences, EAAP: European Federation of Animal Science, APSA: Australasian Pig Science Association, WASS: Wageningen School of Social Sciences, UU: Utrecht University, WGS: Wageningen Graduate Schools, ASG: Animal Science Group.

**One credit according to ECTS is on average equivalent to 28 hours of study load

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