Consumer Valuation Studies and Structural Modelling of the Pig industry

A focus on animal welfare

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Abstract

In this thesis, animal welfare in the pig industry is investigated from an economic perspective. More specifically, the impact of the "Swedish model" on consumers and producer is examined. The "Swedish model" refers to the animal welfare promoting legislations and voluntary certification schemes that was adopted in Swedish pig production from the 1980's and onwards.

The willingness to pay for animal welfare attributes among consumers is investigated in two studies. The attributes analyzed are all related to the "Swedish model" or are practiced experimentally. The consumer's willingness to pay for animal welfare attributes is mostly positive, with a particularly high value for mobile abattoirs and air-partition (fewer pigs per stable section). There is a negative willingness to pay for elimination of castration. Moreover, the heterogeneity of consumer preferences for animal welfare is investigated. Preferences are found to be heterogeneous and the results suggest that consumers' preferences could be divided into different segments. The division into segments is likely to depend on consumers' preferences for animal welfare and food safety issues.

Moreover, the economic implications of the "Swedish model" are investigated in a structural equation model. It is found that the Animal Welfare Act of 1988, the ban of using growth promoters and the space requirements for sows in nursery have affected supply of pigs negatively. If these animal welfare regulations had not been adopted the total production would have increased moderately and the retail price of pork would be lower. Hence, the animal welfare regulations of the "Swedish model" have implied increased costs to the pork sector with higher prices and lower production levels.

Keywords: animal welfare, pig industry, regulations, consumer valuation, choice experiment, structural equation model, Swedish model

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Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Liljenstolpe, C. (2008). Evaluating animal welfare with choice experiments: An application to Swedish pig production. *Agribusiness* vol. (1), 67-84.

II Carlsson, F., Frykblom, P. and Liljenstolpe, C. (2003). Valuing wetland attributes: An application of choice experiments. *Ecological Economics* 1(47), 95-103.

III Liljenstolpe, C. (2008). Demand for value added pork in Sweden: A latent class model approach. Manuscript submitted to *Agribusiness*, revised first round.

IV Liljenstolpe, C., Surry, Y. and Andersson, H. (2008). A quantitative assessment of the Swedish animal welfare regulation: The case of the pork sector (manuscript).

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Abbreviations

wtp	Willingness To Pay
wta	Willingness To Accept
AIDS	Almost Ideal Demand System
RPL	Random Parameter Logit model
LCM	Latent Class Model
RUM	Random Utility Model
CV	Compensating Variation
EV	Equivalent Variation
iid	Independently Identically Distributed
IIA	Independence from Irrelevant Alternatives
LRF	Swedish Farmers Federation

1 Introduction

"While we're waiting for a really stress-free pig, we can soothe the ones who make a fuss when their neighbours in the crowded boxes, for the lack of anything else to do, start snipping of their tails. We can tranquilize them with something called Hogpax. That makes them nice and submissive and more disposed to part with their tail. Now I'm beginning to understand why pork chops don't taste the way they used to." These are the words of the children's book author and public debater Astrid Lindgren[1]. The year was 1985 and the animal welfare debate had just been initialized by a series of debate articles in a Swedish news paper. Three years later a new Animal Welfare Act was stipulated. Its target was to "protect animal from avoidable suffering, to promote animal health and to raise animals in an appropriate environment, adhering to their natural environment" (Government Bill, 1987/1988:93). The Animal Welfare Act was officially the Prime Ministers Ingvar Carlson's birthday present to Astrid Lindgren. At the time, this Act was unique in an international perspective. With it followed stringent regulations regarding farm animal husbandry but there were also voluntary certification schemes, often referred to as the "Swedish model" of animal husbandry (LRF, 2002). Many livestock operations were forced to make structural changes in order to adapt to the new regulations. Building design changed to meet the new requirements of climate conditions, maximum noise level, sufficient light and space. Also, the use of antibiotics as growth promoter became prohibited already in 1985.

When reconsidering the arguments by Astrid Lindgren at the time, we may get a glance of how consumers consider modern farming. The ethical status of animals or to what degree we consider animals as moral objects worthy human consideration, differ widely among people (see Lund et al.

[1] In 'Astrid wants to save the cows' (Lindgren and Forslund, 1990).

(2007)). This has wide impact on how animal production is assessed. Some consumers may believe that conventional production systems are sufficient to provide a good animal welfare standard, while others prefer production systems that are more prone to enhance the natural behaviour of animals. On the extreme, consumers may ignore the responsibility for animal welfare; or non-consumers may claim that humans have no right to use animals or to slaughter animals. In addition to the individuals' differences, the assessment of animals exhibits a cultural relativism. Furthermore, the perception of good animal husbandry is non static; it has also changed over time. Cserhalmi (2004) argues that the importance of "good animal husbandry" has increased over the last 200 years among consumers. During the 19TH century, when there was a constant threat of bad harvest and starvation, consumers considered efficient production equally important to good animal husbandry. But in the late 20TH century, consumers have begun to question the industrialized agricultural production systems.

Along with an increasing human wealth, the demand for animal welfare has also increased. This relatively new public interest has in one respect created an interest conflict between consumers and production. A higher level of animal welfare causes in many cases higher costs of production and the question who should carry the economic burden is relevant. If a higher level of animal welfare is demanded, a larger responsibility could be placed on consumers.

In this thesis, the willingness to pay among consumers for animal welfare attributes is investigated. If there is a willingness to pay for animal welfare in pig production, some of the economic responsibility could be put on the demand side, i.e. on the consumers of pork. Reconsidering the texts by Astrid Lindgren in Lindgren and Forslund (1990), one can foretell an absent vision of and a yearning back to past time, where all animals had a special character and a name. But she also expresses a worry for the safety and quality of the food. Research of consumer preferences indicates that consumer concern for animal welfare has a multidimensional character (see for example Harper and Henson (2001)). Demand for animal welfare could be viewed as an expression of concern for the wellbeing of animals[2] but may also indicate a concern about the welfare of humans. Animal welfare is also held as an indicator of good food standards, i.e. safe and healthy food.

The aim of this thesis is to examine the economic implications of the "Swedish model" in pig production. More specifically the following

[2] The welfare of animals is commonly defined by the five freedoms: 'Freedom from hunger and thirst, discomfort, pain, fear and distress and freedom to express natural behavior' (Council Directive, 1998).

questions are posed: 1) How do consumers value animal welfare attributes of pig production? 2) How can the demand for animal welfare attributes be characterized? 3) Are we able to observe any segmentation patterns in the valuation of animal friendly production? And put in a wider perspective; 4) are there any differences or similarities in valuation of animal welfare and demand for environmental characteristics, e.g. valuation of a common good? 5) To what extent and has the institutional setting of Swedish animal husbandry regulations affected the pig sector? and 6) Would the production have been more profitable if these former institutional changes had **not** been adopted?

In order to perform the analysis, two stated choice experiments on two different occasions have been performed. The survey technology adopted in order to elicit preferences is the choice-based conjoint technique. The random parameter logit (RPL) model is applied in order to account for heterogeneous preferences. Further, a comparison and as a justification to these results, the results from two different models estimations (the latent class model (LCM) and the RPL model) are analyzed and compared.

In order to investigate and simulate the impact of the particular institutional setting with animal welfare regulations adhering to the Swedish model, a sectoral econometric model approach is used. The data used in this study originates from national statistics.

This section of the thesis is organized into three sections. Next follows a discussion of ethical considerations of economic valuation and a definition of animal welfare. Also the main legislative changes adhering to the "Swedish model" is presented. The relevant consumer demand theories are the introduced in order to provide an understanding for how animal welfare may be incorporated into economic theory. This is followed by a presentation of the theory behind the random utility model (RUM) and how this is used in order to derive the specific models used in this thesis. This is followed by a presentation of the demand theories, the Almost Ideal Demand System (AIDS) and the Armington trade model, that explain structural change developments as well as the differentiation between imported and domestically produced pork and different types of meat products. Then some methodological aspects regarding stated choice designs and econometric modelling are discussed. In section 2, the four papers of the thesis are presented and in section 3, a discussion with the main conclusions of the research is made.

1.1 An economic value on natural resources and animal welfare – Ethical considerations and some definitions

When studying animal welfare issues from an economic perspective it is important to make some ethical reflections in these matters. A core question is; can an economic analysis of human demand for animal welfare and hereby "consumer driven" changes in production be defendable from an ethical standpoint? In order to answer this question we could turn to the philosopher Peter Singer, who became one of the front figures of the animal right movements by the book "Animal Liberation" in the 1970's (Singer, 1975). As Singer is a strong proponent of utilitarianism, he uses a normative ethical theory to derive "the right actions" in animal husbandry. Basically, Singer's utilitarianism implies that a main ethical objective should be to satisfy preferences; the moral worth of an action is determined by the satisfaction of the greatest number of preferences.

In a stated choice experiment, individuals make hypothetical choices that are intended to increase their utility. When assuming rational individual behaviour, a satisfaction of preferences is made. If a higher level of animal welfare is demanded, and it is possible to achieve this higher level by paying a higher price, the individual will be more content and happier. A good thing is achieved as human intention is to increase animal welfare or environmental qualities. Then, too some extent, economic valuation of such attributes should be ethical. However, from a utilitarian point of view, also the interests of animals in livestock production are important to consider as these animals may feel pain and suffer and hence are worthy moral concern. The measures of animal welfare in this study, i.e. the animal welfare attributes, are based on how *humans* assess animal welfare. Hence, economic valuation of what humans consider as important for animal welfare may not in itself be an ethical neutral solution to the animal welfare problem. A neutral ethical solution should also depend on the real effects in terms of animal welfare. Consequently, it has to be ensured that animal welfare attributes really contribute to a higher level of animal welfare. If valuation studies into animal welfare really contribute to more content animals, economic valuation can be ethical and hereby a good way to address animal welfare in intensive production systems.

Having discussed the legitimacy of economics in animal welfare analysis, a question that remains to be answered is how animal welfare should be interpreted. There is an extensive literature on how to assess the level of animal welfare (See for example Fraser and Broom (1990), Sandoe and Simonsen (1992), Mason and Mendl (1993) and McGlone (2001)). Although there is no single definition of the topic, there are certain

agreements of principles that can be applied to the entire livestock sector. The indicators commonly used are health (frequencies of illness, fitness), productivity (growth rate, feed efficiency), physiology (visible injuries, heart rate, stress response) and ethology (behaviour in a specific surrounding). Each of these indicators has a potential to provide a measure of the animal's wellbeing. The problem is, according to Mason and Mendl (1993), that these measures are not easy to interpret and do not always co-vary. As a solution to this problem many authors suggest the use of more than one of the indicators when defining animal welfare (Fraser and Broom, 1990; Sandoe and Simonsen, 1992; Mason and Mendl, 1993). In order to have an interpretation of animal welfare, an example of current animal welfare research concerning pig production is provided in Table 1.

Table 1.1 Factors affecting the animal welfare of pigs

Topic	Comments
Transport	When transporting pigs to slaughter the main stress factor for the animal is during loading and unloading (Broom and Trunkfield, 1990; Knowles, 1995; van Putten and Elshof, 1978; Augustini and Fischer, 1982; Bradshaw and Hall, 1998). Excessive use of sticks and electric prod by stockmen as well as slippery floors can exacerbate stress (Tennessen et al., 1985). Relatively small sized herds and short distances between farms in Sweden often necessitate the mixing of unfamiliar animals in order to fill a vehicle. Pigs grouped with unfamiliar pigs during transportation tend to act aggressively, which worsens the animal welfare (McGlone, 1985). Further, transporting on rough and un-surfaced roads shakes the vehicle which makes life uncomfortable for pigs, and can cause travel-sickness (Randell, 1992 ;Tarrant, 1990).
Castration	Castration of male pigs intended for meat production is carried out when piglets are 3-7 days old. Research shows that castration, as it is conducted today without anesthesia, causes severe suffering. Piglets castrated without anaesthesia produce both high and low frequency squeals significantly more often than other piglets in an experiment. In addition, during the first 2 hours after castration these piglets behaved differently compared with non-castrated piglets, spending more time sitting and standing rather than lying (Taylor et al., 2001). It has been discussed whether local anaesthesia should be standard practice when castrating piglets. Studies by McGlone and Hellman (1988) and Lauer et al. (1994) indicate that anaesthesia in various forms can prevent the pain-induced behaviour of castrated piglets. Some countries, Norway for example, have decided to prohibit castration in 2009. However, some boar carcasses have a low quality due to high levels of skatole and androstenone. This is a problematic matter, as aversion towards pork will probably develop among consumers (EFSA, 2004).
Housing condition	In general, as pigs display investigative behaviour, it is assumed that an improved environment is beneficial for welfare (Wood-Gush et al., 1990) A pre-slaughter study showed a significantly greater increase in cortisol level in pigs reared in standard housing systems compared with pigs reared in an improved environment (Klont et al., 2001). Piglets reared outdoors tend to fight less than piglets reared indoors when mixed after weaning (Cox and Cooper, 2001; Webster and Dawkins, 2000). In a study by Bollmann (1991) it was concluded, based on own experiments and the results of Matthews and Ladewig (1994), that welfare in pigs is increased by giving straw bedding followed by contact with other animals and ability to move about. Thus, animal welfare is improved with reduced group size and increased amount of straw in the litter.
Feed	In order to provide a well balanced diet for pigs, the feed should include certain nutritional and digestive qualities (Simonsson, 1997). Thus, a well balanced diet can produce healthier and more productive animals. Domestically and even locally produced feed may not concern animal welfare to a great extent; it is more a case of reliance on national production and food safety among consumers. According to Gregory (2000), one of the main reasons for buying organic food, which is often locally grown, is food safety and personal health.
Mixing pigs	Pigs are often sorted by weight at weaning in order to facilitate an equal opportunity when feeding. The mixing of pigs from several litters into one pen often results in fighting which can lead to higher frequencies of health problems (Fraser and Broom, 1990). According to Lundström and Karlsson (1992), animals belonging to a particular group already have their social ranking established for example when reaching slaughter. Groups of pigs mixed before fattening or before transportation, are known to be more physically active and have more injuries compared with unmixed groups (Warriss, 1994). Further, pigs that fight have a higher level of the hormone cortisol, which shows that fighting is stressful (Warriss, 1994).

In order to meet an increasing demand for animal welfare in agricultural production, Sweden adopted relatively strict animal welfare legislation in the 1980's. This is referred to in the thesis as the "Swedish model". The "Swedish model" may, in an international setting be regarded as unique, not only due to the enforcement of considerable changes in production, but also because of its early timing. The new regulations required considerable changes in housing and management practices, for example ban on sow crates, entirely slatted floors and antibiotics as growth promoter and a gradual increase in minimum space requirements. In Table 2 some of the main legislative changes defined as the "Swedish model" are presented.

Table 1.2 The animal welfare legislation of the "Swedish model" in pig production

Year	**Legislation**
1985	Feeding Stuffs Act
1988	Animal Welfare Act and Animal Welfare Regulation
	Directives on hormone treatment
1989	Directives and advices of animal husbandry
1990	Directives of pre-considerations of new techniques
1993	Directives of animal attendance
	Directives of surgical operation
	Directives of feed
1994	Advices of animal management
1996	Directives on domestic and international live animal transports
2000	Directives and advices of live animal transports
2003	Directives of slaughter and changes of directives
2004	Directives and advices of animal management
	Directives and general advices of animal husbandry
2006	Directives and general advices of transport of live animals
	Directives and general advices of transport of live animals
	Regulations and directives of feed

Antibiotics as growth promoters were banned by the Feeding Stuffs Act by SFS 1985:295. A couple of years later, the Animal Welfare Acts were stipulated (SFS 1988:539, SFS 1988:534). This law differed from all the previous ones in the sense that the animals should be "guaranteed to lie and move freely and to be able to express their natural behaviour". This generated in the following years remoulding changes for Swedish pig husbandry. More stringent rules was stipulated, concerning loose housing, handling, space requirement and some stable environment requirements

(SJVFS 1989:20; SJVFS 1993:154; SJVFS 1993:177; SJVFS 1994:2; SJVFS 1996:105; SFS 1996:721; SJVFS 2000:133; SJVFS 2000:2; SJVFS 2002:1124; SJVFS 2003:6; SJVFS 2003:3).

1.2 Theoretical and conceptual frameworks

How can values such as user– and existence values or animal welfare be measured in monetary terms? The purpose of this section is to provide some insight into how animal welfare or an environmental resource can be viewed in an economic framework. Also, some fundamental concepts on the economic theories that underlie the empirical work in this thesis are presented.

1.2.1 Consumer welfare

The valuation literature in economics is directly related to consumer demand theory. Consumer preferences and utility maximization provide the framework of analysis. Consumers are assumed to exhibit rational behaviour. Thus a change in quantity of a good implies changes in consumers' utility. However, there exist various theoretical frameworks under which this welfare can be measured, by utility maximization or expenditure minimization. For the utility maximization case, the preferences are assumed to be well-defined, i.e. reflexive, complete, transitive, continuous and strongly monotonic. Thus there always exist a continuous utility function and preferences of different consumption bundles. This implies that fixed prices and a budget restriction provide the consumer a possibility to allocate the total expenditure and maximize utility. Solving this problem, we derive the Marshallian demand function, where the welfare change resulting from a change in prices or budget, is captured by a change in consumer surplus (Marshall, 1920). Common valuation methods making use of the Marshallian demand is the travel-cost method initially proposed by Hotelling (1949) or by hedonic pricing methods developed by Harrison and Rubinfeld (1978).

An alternative approach to measure consumer welfare for quality changes is by the Hicksian demand function (Hicks, 1943). The Hicksian demand function is obtained by minimising the total expenditure that is required to achieve a given level of utility. The Hicksian demand function can be derived using Shepard's lemma, i.e. taking the partial derivates of the expenditure function with respect to the prices. Now we assume that the consumer's utility function is defined as U_i (i=1, 2), where i denotes levels of utility. Let us assume that the goods consumed (or demanded) at the market

are perceived level of technical productivity $TP_{1,2}$ and perceived level of animal welfare $AW_{1,2}$. These two commodities can either be consumed at a high or a low utility level, i.e. at U_1 or U_2 (*cf.* Figure 1.1). The slope of the budget restriction m of the consumer is determined by the relative prices of the two commodities $\{\mathbf{x}: p_{aw}AW_1+p_{tp}TP_1=m\}$ where the slope is $-p_{aw}/p_{tp}$ and vertical intercept m/p_{aw}. Utility maximizing behaviour of the consumer subject to the budget constraint implies that optimal consumption of the two different goods is where the budget constraint line is tangent to the indifference curve, i.e. allocated along the $-p_{aw}/p_{tp}$ slope. A change in price levels induces changes in utility levels and can be measured by a change in equivalent or compensating variation, depending on the reference point of utility.

If the reference point is at the initial level indifference curve U_1, a compensating variation will be the maximum amount of compensation the individual is willing to abstain in order to be at the higher animal welfare level AW_2 and remain at the same level of technical productivity. Hence, a movement from U_1 to U_2 is "worth" the compensating variation: $U_2(TP_{1,2}, AW_2\text{-}CV)=U_1(TP_{1,2},AW_1)$.

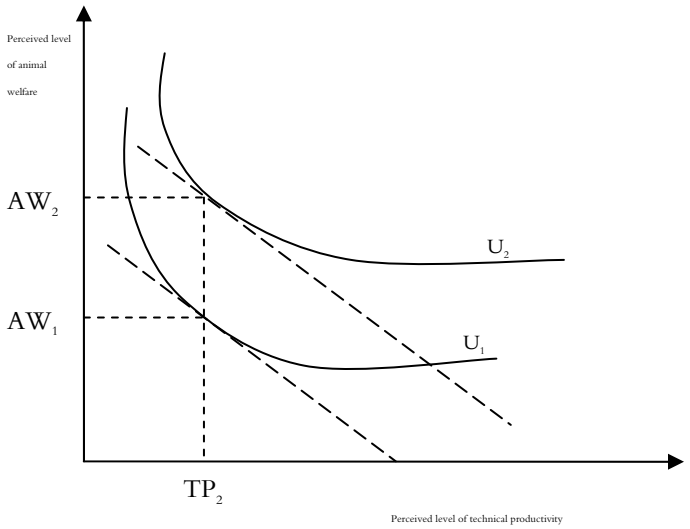

Figure 1.1 Welfare changes measured as compensating variation (*CV*)

On the other hand, if the reference point is the final destination, a higher level on an indifference curve U_2, the equivalent variation can be used to measure welfare changes. The equivalent variation is be interpreted as the minimum amount of compensation the individual acquires in order to remain at the initial indifference curve U_1 instead of being at U_2: $U_2(AW_1, TP_2)=U_1(AW_1, TP_1+EV)$.

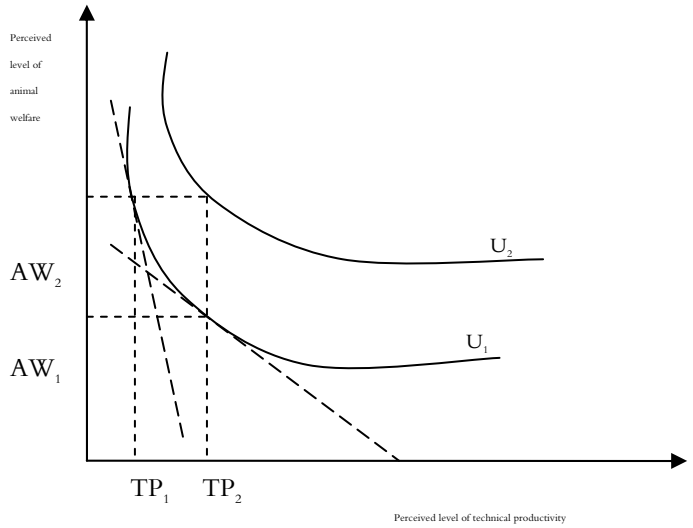

Figure 1.2 Welfare changes measured as equivalent variation (*EV*)

In order to exhibit utility maximizing behaviour, the expenditure function must exhibit homogeneity of degree one with respect to prices, be increasing in utility, non decreasing in prices, concave in prices, continuous in prices and be differentiable.

1.2.2 The Random Utility Model

In this thesis, the consumer utility function is estimated using the discrete choice analysis. The fundamental principle behind discrete choice analysis is utility maximization of an individual. A decision maker is assumed to select a consumption bundle among others that yield the highest utility at that time. The Random Utility Model, RUM, is typically derived from a linear utility function U_{iq} which is the utility derived from an individual *(n)* choosing alternative *(i)*:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \qquad (1.1)$$

The utility function is assumed to consist of two components: a systematic component V_{ni} and a random component ε_{ni}. The individual always chose the alternative that yields the highest utility. Hence the alternative *i* is chosen *iff*:

$$U_{ni} > U_{nj} \qquad \forall j \neq i$$

The probability P_{ni} that an individual *n* chooses alternative *i* is

$$P_{ni} = \text{Prob}\left(U_{ni} > U_{nj}\right) = \text{Prob}\left(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}\right) = \text{Prob}\left(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}\right)$$

This probability can be solved by assuming a distributional form for the random components of the utility functions, ($\varepsilon_{nj} - \varepsilon_{ni}$). The most common model used within the RUM framework is the multinomial logit model (MNL) (Luce, 1959; Marschak, 1960; Luce and Suppes, 1965 and McFadden, 1974). The probability can expressed as a function of the known, systematic part of the utility function:

$$P_{ni} = \frac{\exp \mu\left(V_{ni}\right)}{\sum_{j \in C} \exp \mu\left(V_{nj}\right)} \qquad (1.2)$$

An important feature with the MNL model is that the random components are assumed to be independently identically distributed (iid), which give rise to the well-known feature of independence from irrelevant alternatives (IIA). The IIA implies that the ratio between two different probabilities within a choice set is unaffected by changes in other alternatives in the choice set, which may lead to incorrect predictions. Furthermore, these models do not allow for heterogeneity in taste. In order to incorporate taste heterogeneity in modelling, mixed logit models are often applied (Bhat, 2000; Revelt and Train, 1998 and Train, 1998). These models are defined on the basis of their functional form for its choice probabilities; the mixed logit model are the weighted average of the logit choice probability over different values of β with a mixing density $f(\beta)$.

If the mixing distribution $f(\beta)$ is discrete with a finite set of distinct values(different classes *q*) we have a latent class model (LCM) (Greene and Hensher, 2003; Swait, 1994; Train, 2003). The choice probability of individual *n*, belonging to a class *q* choosing alternative *i* is defined as:

$$P_{niq} = \sum_{q}^{Q} \left[\frac{\exp(\lambda_q I_n)}{\sum_{q}^{Q} \exp(\lambda_q I_n)} \right] \left[\frac{\exp(V_{niq})}{\sum_{j \in C} \exp(V_{njq})} \right] \quad (1.3)$$

where the first, right hand side term, of this expression is the individual probability of class membership and the second right hand side term is the choice probability of individual *n* choosing *i* conditional on membership in class *q*. If the mixing distribution is continuous we have a random parameter logit model, RPL. The utility parameters are assumed to follow a specific distribution (Revelt and Train, 1998; McFadden and Train, 2000). The choice probability of the RPL model is expressed as

$$P_{ni} = \int L_{ni}(\beta_n) f(\beta) d\beta \quad \text{where} \quad L_{ni}(\beta_n) = \frac{\exp(V_{ni})}{\sum_{j \in C} \exp(V_{nj})} \quad (1.4)$$

The choice probability of the RPL models does not have a closed form. Hence these models are relatively computationally intensive and require simulations to be solved. Apart from the ability to model heterogeneous preferences, the RPL and the LCM allow the retrieval of parameters on class- or individual level. If the probability distribution is defined as continuous, individual values of wtp can be achieved using Bayes rule. RPL modelling is applied in paper 1, 2 and 3. A LCM is applied in paper 3.

1.2.3 Structural equation modelling

The microeconomic theory discussed so far is within a static framework. As food items are frequently consumed (and during a long time period) a more relevant analysis may be conducted within a time context. Here the current consumption is assumed to be influenced by consumption in the past, i.e. there exists a degree of persistence in consumption. Also the supply of agricultural sector exhibits a dynamic dimension as output follows biological cycles. In addition, producers' expectations have an influence on the supply of agricultural output. In paper 4, a structural equation model is developed that captures supply and demand for Swedish pork. Standard neoclassical assumptions are applied in order to derive the structural equations. The supply side is defined by total supply of pork, supply of pigs, sow inventory and number of piglets. The sow inventory affects the supply of piglets which

in turn has a direct link to the supply of hogs. The total supply of pig meat is affected by both the sow inventory (sow slaughter) and the supply of hogs.

On the demand side, an Almost Ideal Demand System (AIDS) is applied in a first stage to obtain a theoretically consistent demand for pork, poultry and beef. The consumer is assumed to make a choice between three different meat products: pork, poultry and beef (*cf.* Figure 1.3). The market shares for the different meat products sum to one, i.e. through the "adding up" property. The demand functions are expressed as budget shares spent on the respective meat products. These are derived from a second-order approximation of any utility function (See Deaton and Muellbauer (1980) for a complete derivation of the budget share equations and the AIDS model).

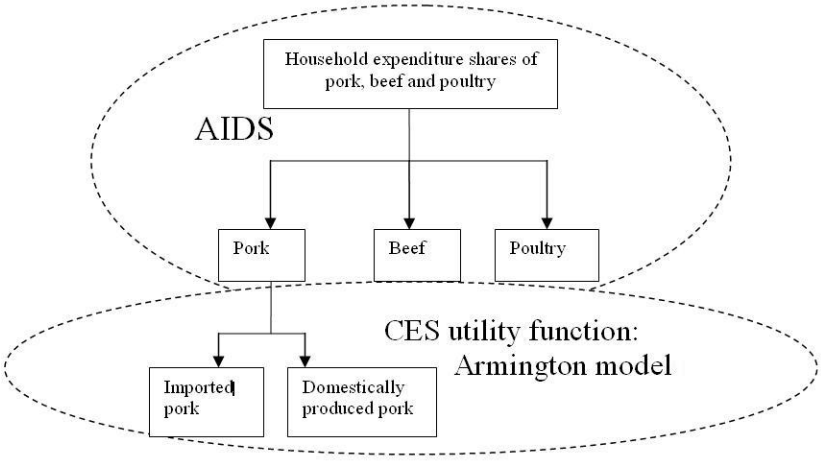

Figure 1.3. The consumer demand for pork in a two stage framework: The relationship between the AIDS model and the Armington model.

The budget share equation of a non-linear AIDS is defined as (Moschini, 1998):

$$w_i = \alpha_i + \alpha_i \log p_i - \sum_{i=1}^{n} \alpha_i \log p_i + \sum_{j=1}^{n-1} \theta_{ij} \log \frac{p_j}{p_n} + \beta_i \log\left(\frac{x}{P}\right) \quad (1.5)$$

where p_i and p_j denote prices, x is total expenditure and P is a translog price aggregator. An attractive feature of the AIDS model is that standard assumptions on economic theory may be incorporated into the model. By

construction, homogeneity of degree zero as well as symmetry of preferences is achieved, i.e. equal proportional changes in market price have no impact on the respective market shares. Furthermore, a change in a commodity *i*'s price will affect *j*'s market share to the same extent as a change in commodity *j*'s price affects *i*'s market share. In addition, by imposing a negative semi-definite matrix $\Theta \equiv [\theta_{ij}]$, a decrease in price *i* decreases the market share for commodity *i*. From the estimated parameters of budget share equations it is also possible to retrieve price- and income elasticities with respect to the different commodities.

Having established the budget shares and demand for pork, a further differentiation between imported and domestically produced pork is included in the modelling framework (Armington, 1969). In the Armington modelling framework it is assumed that imported and domestically produced goods are imperfect substitutes and that the elasticity of substitution between domestic and imported pork is constant[3]. LD_t is the logarithmic demand relation between per capita demand for imported pork and demand for domestic pork. LD_t depends on the relative prices RHP_t^{dom} and RHP_t^{imp} according to a partial adjustment framework, originally developed by Nerlove (1958):

$$LD_t = \alpha A + (1-\alpha) LD_{t-1} + \alpha\sigma \log\left(\frac{RHP_t^{imp}}{RHP_t^{dom}}\right) \tag{1.6}$$

where

$$LD_t = \log\left(\frac{D_t^{imp}}{D_t^{dom}}\right) \tag{1.7}$$

and A is an expression for a preference relation between the imported and domestic pork per capita[4], α is an adjustment coefficient between long and short run, σ is the long run elasticity of substitution between imported and domestic pork. The short run elasticity of substitution between domestic and imported pork can be interpreted as the product of the coefficients $\alpha\sigma$. The price of pork P_t^{pork} can be well approximated by a Divisia price index that is known to provide a good approximation to the CES price index (Diewert, 1976). The Divisia price index is here defined as the weighted average of

[3] A utility function with a CES functional form determines the utility from various combinations of imported and domestic pork.

[4] $A=\sigma \log(b_t^{imp} / b_t^{dom})$, where b_t^{imp} and b_t^{dom} are the respective preference components of a CES utility function: $U_t = C\left[\left(b_t^{dom} D_t^{dom}\right)^{-\sigma} + \left(b_t^{imp} D_t^{imp}\right)^{-\sigma}\right]^{-1/\sigma}$

expenditure shares between imported and domestic pork over two time periods:

$$P_t^{pork} = P_{t-1}^{pork} \exp\left(\frac{1}{2}\left(\left(s_t^{dom} + s_{t-1}^{dom}\right)\log\frac{RHP_t^{dom}}{RHP_{t-1}^{dom}} + \left(s_t^{imp} + s_{t-1}^{imp}\right)\log\frac{RHP_t^{imp}}{RHP_{t-1}^{imp}}\right)\right) \quad (1.8)$$

The budget shares for imported and domestically produced pork, s_t^{imp} and s_t^{dom}, can be defined as:

$$s_t^{dom} = \frac{RHP_t^{dom} D_t^{dom}}{RHP_t^{dom} D_t^{dom} + RHP_t^{imp} D_t^{imp}}$$

$$s_t^{imp} = \frac{RHP_t^{imp} D_t^{imp}}{RHP_t^{dom} D_t^{dom} + RHP_t^{imp} D_t^{imp}} \quad (1.9\ a,b)$$

1.3 Materials and methodological considerations

1.3.1 Empirical material

In this thesis, the demand for a good is measured by wtp. The wtp values are estimated from stated preferences data where the respondents are asked for the wtp of an improvement of a specific commodity. Two different choice experiments have been conducted in order to reveal the wtp values of two different topics. In survey 1, the valuation of a natural resource–a wetland– is measured and this material is used in paper 2. The questionnaire was developed in cooperation with researchers specialized in wetlands from Lund, Linköping and Uppsala University. Prior to that survey, several focus group discussions were conducted from which the attributes have been defined. The main survey was conducted in Staffanstorp community in 2001. Staffanstorp is situated in Southern Sweden and has 15000 inhabitants. The questionnaire was sent to 1200 individuals, chosen from the Swedish census registry. The response rate was 48% and after dropping missing observations, 468 answers were available for analysis. A separate fact sheet was enclosed, where the attributes were explained.

In survey 2, a valuation study of animal welfare is performed which is used in paper 1 and 3. The animal welfare attributes were defined from the literature (*cf.* Table 1.1), current regulation of organic pig rearing, focus

groups and interviews with representatives from consumer associations, the Swedish Farmers Federation (LRF), Swedish Meats and the Swedish University of Agricultural Sciences. The animal welfare attributes of the survey may be attributable to the voluntary rules stipulated in "the Swedish Model" or are practiced experimentally. The main survey was sent out in May 2002 to 3000 individuals in Sweden. The response rate accounted to 45%. Also for this questionnaire, a separate fact sheet was enclosed, in which the animal welfare attributes were explained.

In order to conduct the structural equation modelling in paper 4, data is collected from the yearly publications from Swedish Board of Agriculture from year 1973 until 2006 (SJV), Statistics Sweden databases (2008) and FAO (2008). Data on the Animal welfare variables are collected from Agriwise (2008), Botermans (2003) and Swedish Board of Agriculture (2008).

1.3.2 Some notes on choice experiments and econometric modelling

The choice experiment; a stated preference method, differs from contingent valuation methods in terms of design complexity. In choice experiments, *a priori* assumption is that respondent achieves utility from the characteristics, i.e. attributes, of a good. Within the choice experiment technique several multi-attribute goods can be analyzed against each other, which facilitate a multidimensional survey. Hereby, more detailed information of how respondents make different choices can be attained; however there is a trade-off between detailed information and the complexity of the questionnaire.

A specific case of the choice experiment technique is the choice based conjoint analysis, where the respondent is asked to choose the most preferred combination of attributes, i.e. alternative, amongst others (Louviere and Woodworth, 1983). Design is a vital issue in choice experiments since the choice sets, i.e. the combination of alternatives, determines the accuracy of the estimates. There exists a wide range of literature dealing with appropriate designs of choice experiments (See for example Huber and Zwerina (1996); Kuhfeld *et al.* (1994); Bunch *et al.* (1996)). A common goal is to achieve orthogonal and balanced choice sets, i.e. the attributes are uncorrelated with each other across the choice set and each attribute occurs with equal frequency. With an orthogonal design the level of each attribute varies independently and hence the parameter estimates will be uncorrelated. However, when designing full-factorial choice sets, there exists an almost infinitive range of different choice designs

to choose from which it is not always feasible for practical reasons. But diminishing the number of choice sets, i.e. to use a fractional factorial design, occurs at the cost of quality of design. The variance of the parameters are proportional to the information matrix, hence it is possible to attain a measure of statistical efficiency of the choice set. In order to improve accuracy of the parameter estimates and statistical efficiency and still have a reasonable set of choices, the D-efficiency criterion[5][6] is commonly used for experimental design (Kuhfeld, 2001). He suggests a test procedure based on the full factorial design from which *M* observations are generated and then observations are randomly selected and dropped, using the D-efficiency score as a decision rule. The final choice experiment design has a minimized variance, however an optimal design can not always be guaranteed. For a more detailed discussion regarding this issue see for example Carlsson and Martinsson (2003) or Lusk and Norwood (2005).

In paper 4, a structural model of the Swedish pig sector is specified and implemented using annual data from 1970 to 2004. In the model, the relationships between the variables are based on neoclassical theory. For example, in an equation describing demand for a normal good, the income variable should have a positive effect and price of the commodity should be negatively related to the demand. Yearly fluctuations caused by the biological cycle of supply can be incorporated into the model by a introducing a lag specification. Hence, the structural model approach yields a forecast of future movements based on the causal relation to a set of other variables, i.e. through the estimated structural equation.

An alternative approach to structural equation modelling would be to study the effects from animal welfare legislation over time using time series econometrics. By using time series econometrics, we do not infer any causal relationship concerning the issue we want to measure. Time series econometrics is often convenient to use when there is cyclical pattern in the data. A time series model is less complicated to construct and may have a good forecasting ability. However, the quality of the data suggests that a structural model should be adopted. As annual data is used there is a limited degree of seasonal fluctuation and therefore the data series can be argued to exhibit a stationary process. Further, the estimation of the structural equations reveals no autocorrelation of the error terms, the ordinary least

[5] The D-efficiency score is given by the formula $100\frac{1}{N\left|(X'X)^{-1}\right|^{1/A}}$ where N is the number of observation in the design and A is the number of attribute levels in the design. A perfectly orthogonal and balanced choice set has the maximum possible score 100 and the lowest possible score is 0. In between, the choice set is unbalanced or have correlated attributes.

square estimation is non-violated and econometric modelling can be consistent.

When modelling effects of a policy change within a system of equations, the Lucas critique becomes highly relevant. The Lucas critique applies to empirical forecasting models that use historical data and where predictions of a policy outcome are based on data from periods of time when the current policy regime was not enacted. Hence, the parameters estimated are not policy invariant, i.e. they are likely to change in a changing economic environment.

In the structural model, the use of Armington model implies that we assume that imported and domestically produced pork are imperfect substitutes with a constant elasticity of substitution. This may be a strong assumption to make for the entire time period, as structural change is not accounted for within this approach. In this respect, consider a case when we have a specific demand relation between domestically produced pork and pork imported from Denmark. With constant elasticity of substitution, the demand relation will be unaffected by institutional changes in Denmark. If Denmark would have implemented stricter animal welfare regulation during this period, it would be a reasonable assumption that the demand relation between imported and domestic pork would change. In fact, institutional changes have occurred in Denmark during the time period analyzed. Restrictions regarding growth promoters in feed was introduced in 2000 and also three national legislations concerning housing of sows in new buildings, housing of pigs and piglets and out-door rearing of pigs have been stipulated. But these institutional changes are less extensive than those implemented in Sweden. From a Danish perspective, Sweden is a relatively small importing country and imports are often constituted by specific parts of the carcass. Hence it would be difficult to expect an effect of stricter Danish regulation on the imported quantity from Denmark. However, for further methodological development, it could be appropriate to allow for varying elasticity of substitution between imported and domestic pork over time.

2 Results

This thesis consists of four different papers dealing with choice experiments analysis and structural equation modelling. For article 1 and 2 the main findings in terms of estimated willingness to pay are presented. But also some interest will be devoted to the differences between these studies. The third article uses an alternative approach to model heterogeneous preferences. The fourth article is a study of the economic impacts of animal welfare regulation. The question is if the animal welfare regulations have affected the market and if the regulations had been less strict, would this have been beneficial to Swedish pig producers?

2.1 Article 1: "Evaluating animal welfare: An application to Swedish pig production"

Preferences for food commodities are characterized by diverse preferences (see for example Hu *et al.* (2004) and Verbeke *et al.* (2005)). Ngapo *et al.* (2003) have shown that preferences for same types of pork product differ considerably within and between countries. In order to be able to model the heterogeneous preferences, the RPL model is adopted in this study. Heterogeneity among the respondents is confirmed through the estimation of a MNL model including artificial variables and where a t-statistics is used in order to reveal the randomness of parameters. The data for this study is achieved from a choice experiment study performed in 2002.

The results indicate that the animal welfare attributes 'Mobile slaughter' and 'Stock limit: 100 pigs', are highly ranked among respondents. The attribute 'No castration' is considered as negative. The attribute 'Mobile slaughter' had a relatively high value on sign reversal probability. A histogram plot of 'Mobile slaughter' in Figure 2.1 suggests that this random parameter could follow a normal distribution.

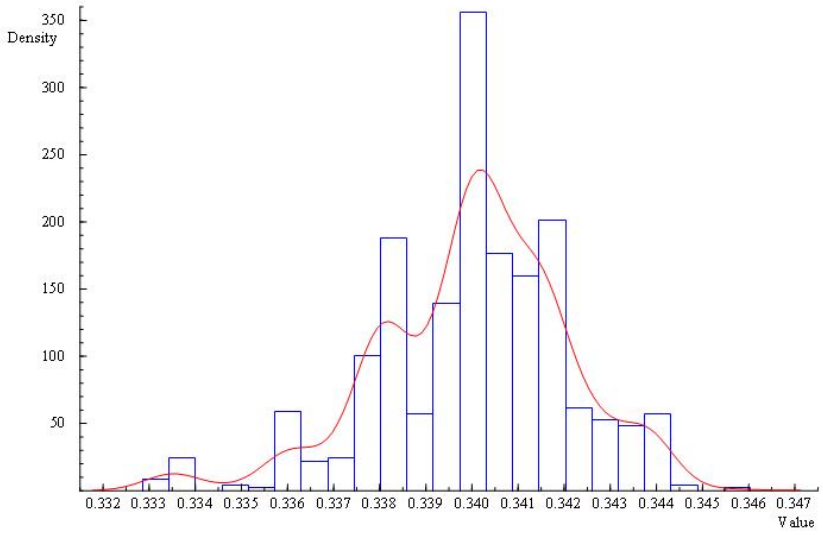

Figure 2.1 The empirical distribution of the random parameter 'Mobile slaughter'.

From this study, we can conclude that preferences are heterogeneous for animal welfare attributes and this motivates the use of the RPL model. In addition, when retrieving the wtp values on individual level for the animal welfare sample it becomes apparent that the distribution is bi-modal for some the random parameters. A histogram plot in Figure 2.2 of mean individual wtp values for the attribute 'Mobile slaughter' shows a segmentation pattern of preferences.

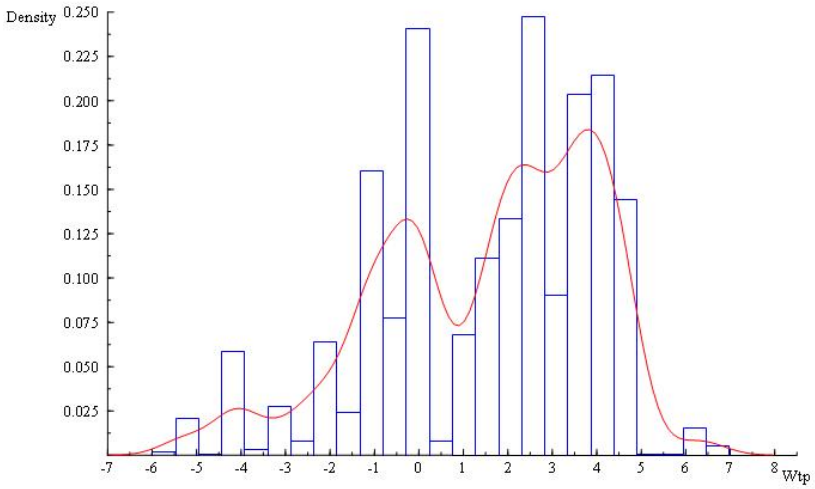

Figure 2.2 Individual marginal wtp for the attribute 'Mobile slaughter'.

The heterogeneity may be viewed as a result of the relatively large amount of attributes in the survey, but it can also reflect a potential segmentation of preferences. This implies that the estimation could be improved by the use of a latent class model, instead of a continuous mixing distribution as in the RPL model. This issue dealt with in a more detailed fashion in Article 3 below.

2.2 Article 2: "Valuing wetland attributes: An application of choice experiments"

The demand for wetland may also be diverse since it may potentially exhibit a various design features depending on geographical location.[7]. A simplified way to divide preferences (or economic value) for a natural resource is into direct and indirect user values, option values and existence values (Pearce, 1993). In the wetland survey, the valuation of 'Walking facilities' and 'High–' and 'Medium biodiversity' was high but 'Fenced waterline' and 'Crayfish' was considered as negative by the respondent. The latter attributes had also a relatively high probability of sign reversal.

[7] The wetland survey was conducted in Staffanstorp community, in Southern Sweden, consisting of 15000 inhabitants. This area is relatively densely populated in Sweden.

The correlation between the random parameters shows that there are strong negative correlations between 'Fence' and 'High Biodiversity' and 'Crayfish' and 'Medium biodiversity'. This may indicate a conflict of different interest into use and existence values. Thus, the model specification could be improved by assuming a discrete support of distribution.

Is it possible to make any conclusions regarding differences in valuation for animal welfare and wetland valuations? First of all, we can state that the two goods differ in the sense that a wetland can be regarded more as a public good or at least a common good and food is a private good. However, both studies indicate that we have heterogeneous preferences for the different attributes. In order to investigate if the respondents' of the wetland survey also have segmentation in preferences, a latent class model is estimated here[8]. A LCM with two different latent classes indicates that the fit is improved[9], however, to a minor extent. The class (68% of the sample) that assign a high value on 'High–' and 'Medium biodiversity' and 'Walking facilities' also dislike 'Meadow', 'Fencing' and 'Crayfish'. The second class (32%) put more value into 'Walking facilities' and 'Meadow' attributes. This segment of respondents also considers 'Fencing' and 'Crayfish' negatively, which indicates that the two last segments exhibit more or less the same preferences. Retrieving the individual wtp estimates from the RPL model also reveals heterogeneous preferences. The individual wtp for the highly quoted attributes 'Medium Biodiversity', 'High biodiversity' and 'Walking facilities' indicate both normal and bi-modal preference distributions. However, the segments for the bi-model case of preferences are all positive. The attributes 'Crayfish' and 'Fencing' have a positive as well as negative segmentation pattern. This indicates that the preferences for these particular attributes are much dispersed.

As a conclusion, it could be argued that respondents of both the animal welfare survey and wetland survey have heterogeneous taste. This may be explained by an underlying segmentation of preferences.

[8]In article 3, a LCM is estimated based on the animal welfare survey.

[9]This is tested according to Greene and Hensher (2003). The Kernel density estimate of the probability ratio of LCM and RPL is skewed which indicate a better fit of the LCM. See article 3 for a more extensive description of the testing procedure.

2.3 Article 3: "Demand for value added pork in Sweden: a latent class model approach"

This paper deals specifically with heterogeneous preferences for animal friendly practices. A latent 3-class model is estimated and the results show that there are three different segments in the population. One segment has a clear animal welfare orientation. Another segment is oriented toward food safety issues. The variable 'No castration' is viewed as negative in class 3 and the same variable has a positive value in class 1. On the other side, the value of 'In-out box' has a positive value in class 1 and negative in class three. As the RPL model and the LCM are non-nested, no conclusions regarding the most appropriate model to use can be made using a likelihood ratio test. Hence, some tests involving choice probabilities suggested by Greene and Hensher (2003) are adopted. The results indicate that the LCM provides a better fit for the survey sample. In order to further investigate the segmentations of the sample, latent membership parameters λ_{FS} and λ_{AW} are used in estimation of latent class probability. The results from this estimation confirm that the sample could have an animal welfare and a food safety orientation. In addition, the interaction between the class membership parameters and an assessment parameter of organic pork is analyzed in a multinomial model setting. Interestingly, the results indicate that the animal welfare oriented class has no belief that organic products are more animal friendly, are safer or have environmental benefits. The food safety class has a strong belief that organic products are environmentally friendly and are safer to eat than conventional products.

2.4 Article 4: "A quantitative assessment of the Swedish animal welfare regulation: The case of the pork sector"

In the fourth and final paper we examine how the "Swedish model" or the animal welfare legislation implemented during the period 1985-2003 has affected Swedish pork production. In order to achieve this information, a sectoral model, based on yearly data from 1970 until 2004, is specified and estimated. The model is intended to depict the biological features of the production cycle. Lag structures are introduced in the sow inventory and pig stock and piglet equation. The demand side is modelled by the AIDS framework and Armington model. Consumers are assumed to consume three types of meat products: pork, beef and poultry and the consumption is measured by budget shares. Imported and domestically produced pork are assumed to be imperfect substitutes and explained by an Armington model specification. A number of identities ensure market clearing for each time-

period. Animal welfare regulations are incorporated into the supply side of the model by continuous variables or by yearly dummies. A set of different hypothetical scenarios is simulated within the modelling framework in order to inquire how the "Swedish model" has affected the Swedish pig production sector. The results indicate that the structural changes due to animal welfare regulations have affected the volume of production and the demand for pork. Simulating a scenario when it is assumed that the use of growth promoters would have continued as in Denmark and that the stricter area requirements for sows in nursery and the animal welfare Act of 1988 did not take place; yields an increase in the total supply of pork and a decrease in price of domestic pork.

3 Discussion

The common aim with this thesis is to investigate the economic impact of animal welfare in the Swedish pig industry. Sweden has in a European perspective a relatively strict animal welfare regulation and has also a long tradition of animal welfare legislation. With the adoption of the Feed directives in 1985 and the Animal Welfare Act of 1988, this country became a forerunner in using animal friendly production system and handling practices. The "Swedish model" in animal husbandry has become a well-known concept.

In the literature there are studies that deal with the real economic impacts of the "Swedish model". The increased production cost due to the ban of growth promoters been assessed to be 0.053 SEK/kg pork for piglet and 0.046 SEK/kg pork for pig production, respectively (Andersson and Jonasson, 1997). Increased floor area as well as the air partition implies increased costs of production (Botermans, 2003; Andersson et al. 2000). Hence the "Swedish model" has implied increased production costs relatively the Danish production. The demand for animal welfare attributes investigated here has also been confirmed by other studies. In a choice experiment study by Carlsson et al. (2007) the wtp values for out-door raised pigs and mobile abattoirs are positive and in Lagerkvist et al. (2006) a ban of castrating piglets is considered negatively by the respondents.

An interesting aspect is whether the animal welfare regulation of the "Swedish model" could be justified from an economic point of view? This question motivates the research into consumer valuation and quantitative modelling of Swedish pig production. As an overall conclusion from the collection of papers in this thesis, it can be stated that animal welfare has, in general, a positive meaning for consumer. Consumers have a positive wtp for attributes such as air partition or a minimum level of straw, which are included in the "Swedish model". But the stricter rules that were introduced

with the "Swedish model" have affected the sector negatively in terms of production levels and high prices. But still, from an economic perspective, animal welfare regulation of the "Swedish model" may be beneficial to implement from an economic perspective as the welfare improvements in terms of consumer valuation, i.e. the wtp values, exceed the assessed increase in retail prices. However, future research should be devoted to investigate the exact welfare impacts at consumer and producer level.

As an overall conclusion, the "Swedish model" is and has been positive for Swedish pig production as it is demanded by consumers and producers. Hence the "Swedish model" should not be viewed as something that has generated costs and a less profitable business for Swedish farmers; instead it should be viewed as a comparative advantage of Swedish agriculture. But in this respect, improvements could be made. The labelling of meat products should be developed further. The fact that animal welfare concerned consumers does not believe that organic pork is produced under more animal friendly conditions is an important result from this study. Hence there should be marketing opportunities for animal welfare labelling such as for example "Freedom Food"[10].

3.1 Some major conclusions

In the introduction section to this thesis a number of questions were raised. In this section we will return to these main topics and discuss the main conclusions.

–How do consumers value animal welfare attributes of pig production?

Animal welfare attributes in pig production are mostly regarded as positive as there is a positive wtp for having the attribute in production. There are especially high wtp values for the attributes 'Mobile slaughter' and 'Stock limit: 100 pigs'. The attribute 'No castration' has a negative wtp.

A common critique against valuation studies is the existence of hypothetical bias and this has been dealt with in a numerous surveys (see for example List and Shogren (1998)). In order to asses the maximum size of a hypothetical bias in the animal welfare valuation, an economic interpretation of the estimated wtp values is provided in Article 1 by a cost benefit analysis for the different attributes. The results indicate that the attributes 'Mobile slaughter', 'Stock limit: 100 pigs', 'Stock limit: 200 pigs', 'No mixing' and

[10] "Freedom Food" is a farm assurance and food labelling scheme dedicated to improving welfare standards for the farm animals reared for food each year in England.

'No castration' could still be motivated from an economic point even though a large hypothetical bias exists in valuation.

–How can the demand for animal welfare attributes be characterized?

Animal welfare attributes have values of different magnitudes, depending on what the consumer considers important. Hence, a high degree of heterogeneity is expected when estimating wtp for a food product. Heterogeneity of preferences is supported in this study by the fact that estimation is improved by a RPL model or a LCM relative to a standard MNL model. Furthermore, there is an improvement in goodness of fit with the two former model specifications. The probability of a sign reversal is high for many of the attributes which support the fact of heterogeneous preferences for the attributes. Sign reversal is sometimes regarded as a problem in econometric modelling (Greene and Hensher, 2003). But for valuation of animal welfare (and also for wetlands), a negative value of wtp may be reasonable. Different signs on wtp may reflect the different ethical statuses humans put on of animals. Some individuals are less anthropocentric and prioritize the value of animals and animal welfare while other individuals are anthropocentric and prioritize the human wellbeing and food safety. Therefore, an attribute may be considered by one individual to be welfare improving as it enhances the welfare of the animal whilst another individual considers the attribute as negative and therefore associates a negative value with it.

–Are there any segmentation patterns in the valuation of animal friendly production?

When retrieving individual estimates on wtp it can be concluded that preferences are not always distributed according to a normal distribution. Histograms of individual wtp values reveal that preferences could be segmented into different classes. From the first article we make the conclusion that consumers put a value on animal welfare attributes, and this value may vary between consumers due to some unknown, underlying explanation. The estimation of a LCM with relevant indicator variables in Article 3 supports the fact that we have segmentation in the sample due to animal welfare and food safety concerns. However, the heterogeneity may be explained by other factors than underlying preferences. Overall, there are eight animal welfare attributes analyzed in the model which is a relatively high figure. Some heterogeneity might reflect the multitude of attributes analyzed in the survey.

–Are there any differences or similarities in valuation of animal welfare and demand for environmental characteristics, e.g. valuation of a recreational good?

The valuation of animal friendly practices can be put into a wider perspective by comparing it with another resource valuation study made in Article 2. It may be concluded that valuation of a natural resource is also characterized by heterogeneous preferences. Several of the estimated attributes have a high significant standard deviation and a high probability of reversed sign. Segmentation of preferences is confirmed by the correlation matrix of the random parameter logit model which reveals that there is a negative relation between the attributes 'Fence' and 'High Biodiversity' as well as between 'Crayfish' and 'Medium biodiversity'. Thus also in the wetland analysis, we may have a segmentation pattern that creates an interest conflict between preferences. Similarly to the valuation of animal welfare attributes, we may both negative and positive values of wtp that reflect the assessed ethical status of a natural resource.

–How has the institutional setting of Swedish animal husbandry affected the pig sector in Sweden?

In Article 4 of this thesis it is found that the 'Animal welfare Act of 1988', the additional directives of 1993 that involves some climate regulations and size requirements, area requirement for sows in nursery and ban of growth promoters have affected the domestic supply of pork negatively. These findings are supported by previous research (Andersson and Jonasson, 1997; Botermans, 2003). The variable for the additional directives of 1993 has a very large impact on the supply of pigs for slaughter. The estimated coefficient value of the year dummy representing the effect of this animal welfare measure is larger than the intercept. This will contribute to an unrealistic scenario where a shock imposed to the dummy variable implies a large upward shift in the supply of pigs for slaughter. This has in turn a decreasing effect on the producer price, which will imply a decreasing effect on the breeding population. Hence, the supply of pigs will increase at the same time as the breeding population decreases. A simulation with the dummy variable for the Animal Welfare Act of 1988, the variables for growth promoters used in production as well as the area requirement give a realistic outcome though. The size of a shift of the supply function as a result from a shock on the animal welfare variables varies between $0.3 \cdot 10^{-4}$ % to a 26% increase.

–Would the production have been more profitable if the institutional changes ***not*** *had been adopted?*

Simulation of the model of the Swedish pork sector indicates that the supply of pork would have been larger if the animal welfare regulations had not been implemented. In addition, the price of pork would have been lower, which contributes to a higher consumption of domestic pork. A policy scenario where the Animal Welfare Act of 1988 is not implemented, the use of growth promoters continues as in Denmark and no increased space requirement for sows in nursery, implies an average increase in total supply of pig meat of 1.5% and a 2.2% average decrease in price of domestically produced pork. The cumulative effects from less stricter regulations would be 2.8% in total supply and 3.8%, in price, respectively. However, an important issue that has been foreseen in the model is the overall awareness for animal welfare over time. The question is if the animal welfare legislation would not have been adopted; would the animal welfare promoting techniques anyway have been adopted into the production? In this respect, one could consider the demand for animal welfare among consumers and producers. As mentioned in the introduction to this thesis, consumers' demand for animal welfare varies between individuals and is non static. The fact that the perceptions of good animal husbandry has changed over time has not been considered in the modelling framework. A likely scenario could be that demand for the animal welfare measures of the "Swedish model" has increased over time. Also Swedish farmers have a demand for animal welfare. In an interview study by Bruckmeier and Prutzer (2007), an overall positive attitude for animal welfare was revealed. Farmers feel responsible to promote animal welfare as far as possible. The animal should be able to express natural behaviour with good feed quality and importance of large pen size. Hence, in the absence of an animal welfare regulation, it could be a likely scenario that animal welfare promoting changes could still have been adopted, due to consumers growing awareness about animal welfare or farmers' belief that animal welfare in necessary in a viable production.

3.2 Contributions of the thesis and suggested topics for future research

The major contribution of this doctoral thesis is the use of empirical methods for valuing animal welfare and natural resources. In the wetland survey, a valuation of the different attributes adhering to a wetland is performed instead of estimating a wtp for the wetland area in itself. A valuation study of attributes solely adhering to animal welfare has not been performed in previous studies. Moreover, the source of heterogeneity in preferences for animal welfare attributes has not previously been investigated. The "Swedish model" is from an international perspective unique. The real impacts from these animal welfare regulations have not yet been estimated in a structural equation model depicting both the demand and supply side of pork production.

The studies into consumer valuation and structural modelling also have created new ideas for a continued research in the topic. Here I suggest four possible extension studies.

Firstly, more research should be put into the segmentation of utility functions and the underlying preferences that determine the behaviour of consumers. In the valuation of consumer preferences in the latent class model, two different class membership indicators were used, animal welfare concerns and food safety concerns. The class membership was determined by the use of dummy variables. In this respect, the criteria under which the class membership is determined could be improved. Therefore future research should develop the methodology behind the determination of class membership and the influence of other possible class indicator criteria as well as class orientations should be further analyzed.

A second relevant topic, related to Article 1 and 2, is to what extent the valuation of different attributes is influenced by the geographical location of the site. A core question is if any general conclusions regarding the demand for animal welfare in the EU can be made from these results. A generalization of the results is of interest as EU has a common animal welfare legislation (EU Council Directive, 1998) and there exists a worldwide interest organization for organic production (IFOAM). Ngapo et al. (2003) report that there are similarities and differences in consumers' valuation between the EU countries. Swedish consumers are concerned about attributes such as 'Slaughtered on farm', 'Raised nearby' and 'From a small abattoir', whilst French respondents show a concern for visual appearance, English for a disease-free pig and Danish for cooking qualities. Hence, the high wtp value for 'Mobile slaughter' may be representative for a Swedish consumer and in order to make the results more general, a benefit

transfer methodology could be adopted (Morrison et al., 2002). Moreover, the Staffanstorp area is a relatively densely populated in southern Sweden and the wilderness areas are relatively few in this part of the country. Thus the specific location of this potential wetland area may have very strong impact on the results. A benefit transfer method has previously been performed on Swedish aquatic sites with choice experiment data (Kataria, 2007).

The third and the fourth topics relates to Article 4. The "Swedish model" constitutes a unique example where data of legislative changes can be attained for a relatively long time. These data may provide some interesting information on how domestic production has been affected over time. However, according to the Lucas critique, the parameters of the structural model are not policy invariant, i.e. they are likely to change in a new policy environment. Structural change is most likely an ongoing process. In the Armington model the consumers are assumed to exhibit constant elasticity of substitution over time between imported and domestically produced pork. Hence, effects of structural change are not completely adopted within this modelling framework, as changes in preferences are not accounted for. Changing preferences is a likely scenario as institutional changes not only occurs in Sweden. During the time of analysis, animal welfare legislations concerning for example antibiotics as growth promoter, has been introduced in Denmark. If consumer put a value on animal welfare, these implementations should have an effect on the substitution ratio between domestic and imported pork The Armington model could be further developed in order to incorporate changing preferences over time.

A natural extension to article 4 would be to incorporate supply equations of poultry and beef into the supply side of the model. In this way, a more complete analysis could be provided on the effects from the "Swedish model" in Swedish animal production. Moreover, in 2005, the Swedish government stated that in 2010 at least 25% of the food consumption in Sweden should be organically produced (Government Communication, 2005). As the organic pig production has stricter rules regarding handling practises, this implies that a considerable share of the domestic pig production and import patterns would change. Hence, it could be of interest to investigate the overall economic impacts from these directives and how conventional, organically produced and imported pork are related.

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