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Societal attitudes towards in ovo gender determination as an alternative to chick culling

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Abstract In ovo gender determination of incubated eggs can be a large-scale substitute to the culling of male chicks in layer hen production. However, the technology raises new ethical concerns which relate to the sensitivity of the embryo, as well as how the screened out eggs will be used afterwards and the accuracy of gender determination. In order to comprehensively investigate consumer attitudes towards this new technology, a questionnaire including a choice experiment was distributed to a representative sample of 482 German consumers between December 2018 and March 2019. The data was analyzed by an explorative factor analysis and a latent class analysis. Results indicate that the sample can be divided into four segments, which differ in preferences for production attributes, attitudes and price sensitivity. Attitudinal differences are found regarding respondents' approval of the technical advances in agricultural production, confidence in legal regulations and the endorsement of enhanced livestock production conditions. Both a meaningful usage of by-products and a high rate of accuracy are crucial factors for the acceptance of in ovo gender determination for the majority of respondents. However, response behavior of one segment, representing 11% of the sample, indicates the disapproval of both chick culling and in ovo screening.

Keywords: chick; choice experiment; culling; gender determination; in ovo; latent class

1. Introduction

Approximately 330 million day-old male chicks are culled annually in the European Union (EC 2008). Culling is a result of advanced specialization in poultry production with layer strains which are characterized by a slim physique and low fattening performance. These properties make them unprofitable for meat production, when competing with conventional broiler meat (Koenig et al. 2012). Also sperm sexing, as is performed for other species, is not feasible for poultry (Nanda et al. 2000; Vishwanath and Moreno 2018). Therefore superfluous chicks are eliminated either by asphyxiation with CO2 gas or by maceration (EC 2008). The economically motivated culling of male chicks without a later use for them in food production is currently being debated critically in a number of western societies, e.g. the Netherlands or Germany (BMEL 2017; Leenstra et al. 2011; Woelders et al. 2007).

An alternative to circumvent chick culling at a large scale is so called “in ovo” (within the egg) gender determination. The technology allows the identification of male chicks already during incubation within the egg. Two technologies are expected to be ready for the market in the near future. They are executed at different stages of embryonic development. The first is a method determining the gender on day 4 of incubation by a spectroscopic analysis of extraembryonic blood vessels (Galli et al. 2017). The second method analyses the estradiol content of allantoic fluid on day 9 of incubation (Weissmann et al. 2013). A third possibility is currently under discussion, which is aiming to analyze the gender through magnetic resonance. It might offer the possibility to sex eggs within the first day of incubation, but it is currently not clear on which level of precision or when it will reach market maturity (TUM Press statement 2018).

The governments along with representatives of the industry (see United Egg Producers 2016; Unilever 2018) announce the approval of these in ovo technologies. In the Netherlands, the parliament has initiated research on potential alternatives to chick culling (see Leenstra et al. 2011). In Germany, the development of an in ovo technology is currently being funded by the government, its large-scale introduction is scheduled for 2020 (BMEL 2017). In ovo gender determination is expected to be one of the major changes in poultry production over the next few years.

From an ethical point of view, one decisive factor for the evaluation of in ovo gender determination is the moral status given to chicken embryos or fetuses. A widely applied principle is that moral status depends on the ability to suffer (Bentham and Browning 1843; Singer 1975), which was considered to be more important than the ability to think (Bratanova et al. 2011; Loughnan et al. 2010). Consciousness and sensation are preconditions for the ability to suffer, normally being applied soon after birth (Mellor and Gregory 2003). Before birth, their determination is less straightforward (Mellor and Diesch 2006). In chicken embryos, some uncertainty about the onset of sentience still remains. It is not possible before the 7th day of incubation, developing stepwise from day 7 on (Aleksandrowicz and Herr 2015). At day 13, the brain is fully developed. Between days 7 and 13, pain perception can be possible, the degree to which it is actually experienced by the embryo is not certain yet (Bjørnstad et al. 2015; Eide and Glover 1995). Mellor and Diesch (2007) argue that chicks are unconscious and in a sleep-like state until at least day 17. In contrast the Guidelines of the American Veterinary Association (Leary 2013) presume consciousness at 50% of incubation time, therefore at day 10.5.

Given this ethical background about in ovo gender determination, it is not surprising that its potential implementation raises ethical questions (Bruijnis et al. 2015) and is exposed to criticism by the public, as has been shown in former studies: Leenstra et al. (2011) conducted a consumer study in the Netherlands and found ethical concerns among respondents towards the destruction of embryos. Sexing freshly laid eggs was considered acceptable (although this is currently not feasible) while destroying late embryos, in opposition, was not. A consumer study conducted in Switzerland by Gangnat et al. (2018) found a preference for in ovo sexing of fresh eggs over chick culling, but did not distinguish between the different technological alternatives. Gremmen et al. (2018) investigated Dutch respondents' approval of in ovo sexing at days 9 and 11 of incubation. Sexing at day 9 was described as "invasive" (taking a sample from the egg) and was found to be an acceptable option by 37.5% of respondents, while a further 33.5% found it unacceptable. Sexing at day 11 was in contrast described as "non-invasive" and was rated as acceptable by 42.3% and unacceptable by 28.2% of respondents. Reithmayer and Mußhoff (2019) used a segmentation-approach and found wide approval among German respondents for the in ovo technology, described as performed before the onset of pain perception. Almost three quarters of respondents were in favor of in ovo screening; however 27% preferred less specialized dual-use poultry as an alternative to chick culling.

Besides the day of gender determination, other crucial factors might raise or decrease acceptance of the technology. A high error rate in gender determination or negative influence on hatchability might influence the acceptance for in ovo screening adversely. These factors would result in a higher number of animals needed and a higher input of resources as energy and fodder. Another crucial factor is the utilization of by-products, namely screened out eggs or male chicks. A meaningful use of by-products could be shown to be a determinant of consent for the respective alternative (Leenstra et al. 2011). It is not intuitive that respondents consider this production characteristic to be important, as this feature has no discernible influence on animal welfare or on the main product (consumption eggs). However, in the related context of pro-environmental behavior, willingness to pay (WTP) a premium e.g. for environmentally friendly production standards or recycling could be found in a number of studies (Aadland and Caplan 2003; Royne et al. 2011). Furthermore, the implementation of in ovo screening will result in higher production costs for consumption eggs. In ovo screening is supposed to be implemented in hatcheries, once it is inexpensive and the extra costs per egg are kept marginal. However, certain consumer segments are very price sensitive (Reithmayer and Mußhoff 2019; Kontoleon and Yabe 2006), thus this factor must be considered.

To the best of our knowledge, studies comparing consumer acceptance for in ovo gender determination at the specific days 1, 4, and 9 of embryonic development as alternatives to the culling of male chicks are lacking. Furthermore, crucial factors that might influence the consumers' evaluation of in ovo gender determination as the utilization of screened out eggs, increasing production costs and the error rate in gender determination have not been subjects of investigation so far.

The aim of this study is therefore to identify and describe groups of consumers based on their attitudes towards in ovo gender determination. Specifically, there are two objectives: 1) identifying whether there are groups of consumers with different attitudes towards the characteristics of in ovo gender determination (using an explorative factor analysis and a latent class approach); and 2) determining, whether the membership in groups is associated with other characteristics; namely attitudes towards technical advance and legislation associated with livestock production and willingness to pay for enhanced animal welfare.

For this purpose, a questionnaire including a discrete choice experiment (DCE) and Likert Scale attitudinal questions was conducted with 482 German consumers between December 2018 and March 2019. The sample is almost representative for the German population regarding the distribution of age, education, residence (rural or urban) and occupational group. Insights from the study provide information for stakeholders in egg production, governments and researchers. Findings should be understood as guidelines in the search and implementation of a publicly accepted and morally preferable substitute to the current practice of chick culling.

The paper is organized as follows. In the next section, the experimental design is described. Subsequently, the econometric model (the latent class model (LCM)) of the study is presented. In the fourth section, results from the factor analysis and the LCM are presented. Results are discussed subsequently and a conclusion ends the article.

2. Experimental Design

2.1. Data Collection

The anonymous online survey was distributed to respondents via an online panel provider (respondi AG, Cologne, Germany) between December 2018 and March 2019. The company manages a pool of potential respondents and offers an expense allowance as an incentive for successful participation. The expense allowance amounted about €3 for the presented survey. Quotas on the respondents' age and highest educational attainment were applied to the survey, in order to obtain a representative picture of the German population. Furthermore, emphasis was taken to achieve a sample which is geographically well distributed over Germany by implementing quotas on participants' postcode (the quota was applied to the first number of the five-digit postcode; this corresponds in approximation to the distribution of the population in the different German federal states). The questionnaire consisted of four parts: first, respondents were asked to give information about their socioeconomic data. Second, two informational texts on the culling of day-old chicks and the in ovo technique were provided, which were essential for the understanding of the DCE. The texts focused on respondents' understanding of the current practice and of the attributes used in the DCE. Participants' understanding was verified through the inclusion of two multiple-choice control questions, which were placed immediately after the informational texts. If respondents answered wrongly, they were provided both the informational text and the control question a second time. If they gave a wrong answer a second time, they were screened out as careless response behavior has to be assumed here. The informational parts were then followed by the DCE (third part). An explanation of the used attributes remained available to respondents throughout the DCE by means of mouse-over buttons, which were included in each choice set. Fourth, important aspects about respondents´ attitudes towards livestock farming, their WTP for enhanced livestock production conditions and their affinity towards technical solutions in order to improve animal welfare were measured by means of five-point Likert-scaled items. Here, too, a quality control was established: one of the Likert Scale questions read "please choose *rather disagree*" and participants who answered incorrectly were screened out.

2.2. Discrete choice experiment

By employing a stated preferences approach, DCEs allow for conclusions to be drawn from previously non-articulated attitudes (Louviere et al. 2010). Through an attribute-based measuring approach, respondents' preferences are investigated by a scenario of hypothetical decision-making situations (List et al. 2006). Because there is no data available about the preferences of German consumers for the in ovo gender determination, using a DCE is advisable. Beforehand, an experimental design must be developed, imposing initial predictions on relevant characteristics of in ovo gender determination.

The attributes and their levels were chosen based on the premises of relevance and complexity of the experiment. Both points were addressed by reviewing the literature and conducting a pilot study with a DCE with 38 respondents, as recommended by Lancsar and Louviere (2008). The attributes in the pilot study were identical to those of the final experiment. The following four attributes were considered pertinent for the sake of this study: (1) the DAY of gender determination, (2) the USAGE of screened out eggs or male chicks, (3) the ERROR RATE, including incorrect gender determination and lower hatchability and (4) the COST INCREASE of in ovo sexing compared to the current practice, described as price increase per box of 10 fresh eggs (10 eggs is a common package size in Germany).

All attributes of the DCE are described through different levels. A summary of attributes and levels is provided in Table 1. The day of in ovo gender determination, as derived from the literature and the current political discussion, is prospectively day 4 of incubation (Galli et al. 2017) or day 9 of incubation (Weissmann et al. 2013). A further approach attempts for gender determination at day 1 (TUM Press statement 2018). In the DCE, the in ovo gender determination is compared to the current practice of chick culling at the day of hatch (day 21).

Table 1 Attributes and levels of the choice experiment

Attributes	Levels
DAY	day 1 | day 4 | day 9 | day 21 (chick)
USAGE	Throwing away (no use) | Chemical industry | Pet food | Fodder
ERROR RATE	1% | 5% | 10% | 15%
COST INCREASE	€0.00 | €0.30 | €1.00 | €1.70

The later use of incubated eggs or chicks depends on the state of embryonic development. Eggs can be used as pet feed, livestock fodder component or in the chemical industry, whereas chicks are currently mainly used as pet feed (EC 2009). Depending on the current market situation, it might occur that chicks or eggs would also be thrown away as waste.

The error rate in gender determination can lead to unintentional destruction of eggs with female embryos. Furthermore, examination of eggs can result in lower hatchability. Galli et al. (2017) find a rate of accuracy in gender determination of >90% for the spectroscopic method performed on day 4, with a hatching rate of >95% in comparison to the control group (Krautwald-Junghanns et al. 2018). For the endocrine method performed on day 9 and presented by Weissmann et al. (2013) the hatching rate was reduced by 1.4 to 12.7 percent points, depending on the test group. The accuracy of determination was above 98%. Also when sexing male chicks, a certain error rate applies (Biederman and Shiffrar 1987). We set the error rates in the range between 1% and 15% for this DCE.

The current practice of chick culling is the most inexpensive alternative to handle superfluous male chicks. The introduction of in ovo gender determination will therefore result in a price increase of consumption eggs. Leenstra et al. (2011) found positive WTP for alternatives to chick culling for the majority of respondents, ranging from the statement to be willing to pay an additional "€0.05 - €0.10 per egg" to "double the price or more"[1]. The study derives the levels of the price attribute on the basis of these statements; they range from no increase in price to an increase of €1.70 per box of 10 eggs.

For this study, an unlabeled experimental design with two generic alternatives and an opt-out alternative[2] was chosen. The opt-out alternative was included to avoid forced responses, which could lead to inaccuracy and inconsistency with demand theory (Hanley et al. 2001). With two generic alternatives, comprised of four attributes with four levels each, the full-factorial design consists of 65,536 possible decision situations (choice sets). However, for the sake of practicability, this design was determined to be too extensive. To minimize the loss of information when reducing the full factorial design, a so-called "efficient design" was applied (Rose and Bliemer 2009). Following the information received from the pretest, a D-efficient design with eight choice sets was found to be appropriate for our purposes (D-error: 1.82) and was computed using the software *ngene* (ChoiceMetrics 2014).

3. The Latent Class Model

DCE have been widely applied to investigate consumer attitudes towards private and public goods (Risius and Hamm 2018; van Wezemael et al. 2014) and are based on random utility theory (McFadden 1986). It is assumed that utility gained from an alternative can be understood as a linear combination of utilities from the alternative's attributes, denoted V_{ij}, and a random term, ε_{ij}. While the former is observable for the researcher, the latter remains unobservable and is assumed to follow a

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[1] The cost of an egg ranges from a minimum of €0.11 for conventional barn eggs to around €0.50 for organic eggs

[2] The opt-out option can be chosen by consumers if none of the given alternatives is assumed acceptable. This applies for instance if other alternatives for handling male chicks are preferred, or if the combination of levels does not meet their preferences.

type I extreme value distribution (Train 2009, p. 34). Assuming an individual i who chooses alternative j from a set of alternatives J_i, the utility can be written as $U_{ij} = V_{ij} + \varepsilon_{ij}$. The observable part of utility is described through the vector of attributes relating to alternative j, labeled x_{ij}, and the corresponding parameter vector: $V_{ij} = \beta' x_{ij}$. The choice probability, as applied in the multinomial logit model (MNL), can be written as (Train 2009):

$$\mathbf{P_{ij}} = \frac{e^{V_{ij}}}{\sum_{j=1}^{J} e^{V_{ij}}} . \qquad (1)$$

The MNL model is based on the assumptions that preferences among surveyed individuals are homogeneous and utilities of different alternatives are uncorrelated (assumption of independence of irrelevant alternatives, IIA). In reality, these strong assumptions are often violated, leading to inconsistent model estimates (Hausman and McFadden 1984).

Other econometric models relax these assumptions to allow for a more realistic approach. The LCM for example is more flexible. It accounts for heterogeneity in preferences (Greene and Hensher 2003) by assuming that the population consists of a number of segments (so called classes). While preferences differ between classes, they are considered homogeneous for individuals within one class. In this way, a discrete distribution of preferences is assumed. The number of classes is defined by the researcher. It depends on the model fit but also on the research question and individual judgement (Swait 1994). Segmentation of the sample is then performed endogenously based on respondents' choice behavior, and socioeconomic or attitudinal variables, if included in the model.

For the following explanations please refer to Greene and Hensher (2003). In a panel data setting, as applied to this study, an individual i faces a series of choice situations t. The choice probability for the LCM depends on class assignment q:

$$\text{Prob (choice j made by i in situation t | class q)} = P_{it|q}(j) = \frac{e^{V_{itj|q}}}{\sum_{j=1}^{J_i} e^{V_{itj|q}}} . \qquad (2)$$

The parameters in the observable part of utility are now class-specific, indicated by the suffix q. For the present study, this part consists of the attributes described in Table 1. The joint probability for the sequence of choices can be written as:

$$P_{i|q} = \prod_{t=1}^{T_i} P_{it|q} \,. \tag{3}$$

The probability for a class assignment is unknown. We define the prior probability for class assignment H_{iq} as:

$$H_{iq} = \frac{e^{z_i'\theta_q}}{\sum_{q=1}^{Q} e^{z_i'\theta_q}} \qquad q = 1, \ldots\ldots, Q; \quad \theta_Q = 0. \tag{4}$$

z_i represents observable characteristics which influence class membership. In the case of the present study these consist of the factor scores obtained from factor analysis. θ_q are the corresponding parameter vectors. This vector is normalized to 0 for the Qth class to secure identification of the model. The choice probability for each individual i given the class membership q becomes:

$$P_i = \sum_{q=1}^{Q} H_{iq} P_{i|q} \,. \tag{5}$$

Estimates for the structural parameter vectors β and the latent class parameter vectors θ are received using maximum likelihood estimation. The attributes, except COST INCREASE and ERROR RATE, enter the model as effects coded variables[3]. The individual-specific characteristics enter the model as dummy coded variables.

4. Results

4.1. Sample characteristics

A total of 544 respondents completed the questionnaire. Respondents needed on average 26 minutes to complete the questionnaire with a median of 24 minutes. To ensure the quality of the data, participants who had always given the same answer in one or more sets of the Liker Scale attitudinal questions or who had always chosen the same alternative in the DCE were removed from the dataset, as inaccurate

[3] Effects and dummy coding differ in the handling of the attribute level which describes the base level. With dummy coding, all non-omitted levels are coded as 0 when the base level is present. With effects coding, all non-omitted levels are coded as -1 when the base level is present (Hauber et al. 2016). The latter avoids confounding with the opt-out option. For a discussion on effects coding in DCE see Bech and Gyrd-Hansen (2005).

answering behavior must be assumed in these cases. After the exclusion of these participants, 482 respondents remained in the dataset. The sample was achieved to be almost representative for the German population regarding the variables age and education (highest educational attainment). The sample is furthermore representative regarding respondents' residence (rural or urban) and occupation group. This can be seen in Table 2.

4.2. Explorative factor analysis

The information about respondents' attitudes collected in the last part of the questionnaire was used to conduct an explorative factor analysis. The factor analysis is valuable to reduce the number of items and to identify the central dimension describing the respondents´ attitudes. Subsequently, the extracted factor scores were included into the econometric model for the latent class analysis (LCA).

Table 2 Socioeconomic characteristics of the sample (n=482)

Variable		Mean (SD)	Percentage %
Average age		49 [50]†, ‡ (17.6)	
Gender male			44 [50]‡
Education	Apprenticeship		51 [56]‡
	University degree		19 [18]‡
	School leaving certificate or none		30 [26]‡
Residence	Rural residence (town <20,000 inhabitants)		48 [41]§
	Urban residence (town > 500,000 inhabitants)		19 [17]§
Occupation	Students		4 [3]††
	Employees		50 [50]††
	Pensioners		35 [26]††
	Other		11 [21]

† German average given in parentheses []
‡ Destatis (2017)
§ Destatis (2018)
†† Destatis (2019)

In a first step, respondents' answers to 26 five-point Likert Scale questions on opinions about animal welfare in livestock production, WTP for enhanced production conditions and attitudes towards technological solutions in modern agriculture were used for an explorative factor analysis. Computations were performed using the package *psych* in R (Revelle 2018). Bartlett test indicates that the data is suitable for factor analysis ($p<0.00$). The overall Kaiser-Meyer-Olkin criteria is 0.88 and

MSA values are >0.65 for all single variables. Velicer's MAP test (Velicer 1976) indicates that 3 factors are most suitable to summarize information from the 26 variables.

We run a maximum likelihood factor analysis with varimax rotation and keep variables with factor loadings ≥0.4 or ≤-0.4 on one factor and a minimum difference to the second highest factor loading of at least 0.2. Ultimately, 18 variables remain in the dataset, loading on 3 factors. Cronbach's alpha indicates good to acceptable values of 0.89, 0.7 and 0.74 (Brace et al. 2018) for factors 1, 2 and 3. Factor loadings can be seen in Table 3.

Table 3 Factor loadings from explorative factor analysis (n=482)

	Mean[†] (SD)	Factor 1 Enhanced animal welfare	Factor 2 Technological advance	Factor 3 Legal standards
Animal welfare is very important to me. I express this through a willingness to pay.	3.77 (1.06)	**0.77**[‡]	-0.10	-0.08
Animal welfare is to be improved, even if this makes food more expensive.	3.95 (1.00)	**0.75**	-0.04	-0.21
When buying animal products, I pay attention to how the animals were kept.	3.52 (0.95)	**0.75**	-0.06	-0.02
I prefer products from housing systems that are above the legal standard.	3.87 (0.90)	**0.70**	0.03	-0.12
I would like to receive more information about the production conditions of food.	3.86 (1.02)	**0.69**	-0.02	-0.16
I am interested in livestock farming in Germany.	3.61 (0.96)	**0.65**	0.02	-0.10
The purchase of animal welfare products has an impact on animal welfare on farms.	3.73 (0.91)	**0.52**	0.16	-0.05
Animal welfare is a question of morality, not money.	4.02 (0.99)	**0.51**	-0.09	-0.08
Imported products from outside Germany should be produced according to the same animal welfare standards that apply in Germany.	4.28 (0.77)	**0.42**	0.11	-0.11
I am well aware of the conditions under which animals are kept.	2.98 (0.89)	**0.41**	-0.12	0.07
I do not check the information on food packaging.	2.31 (1.07)	**-0.56**	-0.13	0.05
To be honest, I don't think much about animal welfare in agriculture.	2.57 (1.15)	**-0.73**	0.14	0.07
Technical progress in agriculture is helpful in solving animal welfare problems.	3.57 (0.87)	0.09	**0.60**	0.08
The use of modern technology in animal production is part of the agriculture of the future.	3.81 (0.82)	0.01	**0.59**	0.06
Animal welfare and modern technologies are incompatible for me.	2.57 (1.04)	-0.02	**-0.62**	-0.01
The technical progress in agriculture is uncanny to me.	2.69 (1.12)	0.17	**-0.63**	-0.06
The welfare of the animals is ensured by the current statutory animal welfare standards.	2.46 (0.88)	-0.16	0.08	**0.73**
I have confidence in German animal husbandry.	2.63 (0.90)	-0.14	0.14	**0.75**
Cronbach's alpha		**0.88**	**0.70**	**0.74**

[†] Sample mean of five-point Likert Scale questions. Value 1: "fully disagree" to 5: "fully agree".
[‡] Highest factor loadings are marked bold

Factor 1 can be summarized as “enhanced animal welfare”, as statements indicating a high affinity to improved animal welfare, a high WTP for enhanced production standards and a high demand for product information are loading on this factor. Factor 2 is named “technological advance”, as statements approving technological solutions in agriculture are loading high on this factor. Factor 3 is called “legal standards”, as it indicates trust in the legislation of livestock production in Germany.

4.3. Results from the latent class model

The data from the choice experiment was analyzed through a LCA. Factor scores from the explorative factor analysis were included as individual-specific variables into the LCA. Models were tested with 2 and up to 7 classes. The Bayesian Information Criterion (BIC; Schwarz 1978) was then used to identify the appropriate number of classes, as recommended by Roeder et al. (1999). BIC reaches a minimum at Q=4, as can be seen in Table 4, indicating that heterogeneity in respondents’ attitudes can best be described through 4 segments. McFadden R^2 for the model with four classes is 0.25, indicating a good explanatory power (Louviere et al. 2010, p. 54). The results of the four-class model subsequently are presented in Table 5.

Table 4 Bayesian information criteria[†] (BIC) of models with a different number of classes (n=482)

Number of classes Q	Q = 2	Q = 3	Q = 4	Q = 5	Q = 6	Q = 7
BIC	6,990	6,796	6,740	6,746	6,831	6,890

[†] $BIC = -2 \log L + p \log(n)$
with p the number of free model parameters and n the sample size

The smallest class makes up 11% of the sample, whereas the largest class represents 41% of respondents. Statistically significant coefficients are found for all classes. For class 1 (11% of the sample), statistically significant negative coefficients are found for the ASC and the attribute ERROR RATE, while all other parameters are not statistically significant. That means that members of this group on average prefer to opt out, and they disapprove inaccuracy in the gender determination process. Due to the tendency to opt out, class 1 is named “the refusers”. Members of class 1 are widely indifferent about the remaining characteristics of the in ovo technique. This class seems to follow other criteria in their evaluation of in ovo gender determination or may have no clear opinion about the insignificant attributes. The results can be an indicator that class 1 approves neither chick culling nor in ovo gender determination, but would be in favor of other solutions as e.g. dual-use poultry, which were not given as an alternative.

Table 5 Estimation results of the LCM[†] with four classes (n=482)

	Class 1 *The refusers*	Class 2 *The ethicists*	Class 3 *The technology-savvy*	Class 4 *The eager ones*
Shares	11%	41%	20%	28%
ASC[‡]	-1.90*** (0.43)[§]	0.85*** (0.16)	1.35*** (0.22)	4.00*** (0.49)
Day 1[††]	0.03	1.97	-0.07	0.97
Day 4	0.03 (0.28)	1.19*** (0.11)	0.37** (0.14)	0.95*** (0.20)
Day 9	0.04 (0.29)	-0.65** (0.22)	0.48** (0.16)	0.31* (0.13)
Day 21 (chick)	-0.10 (0.42)	-2.51*** (0.22)	-0.78*** (0.18)	-2.23*** (0.41)
Waste[††]	0.04	-1.42	-0.71	-1.15
Chemical industry	-0.19 (0.34)	-0.35** (0.13)	-0.67*** (0.17)	-0.32* (0.12)
Pet food	-0.10 (0.40)	1.02*** (0.16)	0.92*** (0.17)	0.84*** (0.15)
Fodder	0.25 (0.28)	0.75*** (0.09)	0.46** (0.17)	0.63*** (0.10)
Error rate	-7.64* (3.44)	-16.64*** (2.01)	-5.21*** (1.55)	-9.99*** (0.98)
Price	-0.22 (0.32)	-0.54*** (0.13)	-1.72*** (0.23)	-0.56*** (0.13)
Constant		1.30*** (0.07)	0.57*** (0.08)	0.92*** (0.07)
Factor 1		0.03 (0.06)	-0.08 (0.07)	-0.07 (0.06)
Factor 2		0.01 (0.07)	0.23** (0.08)	0.10 (0.07)
Factor 3		0.34*** (0.07)	0.05 (0.08)	0.21** (0.07)

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001
[†] LCM, latent class model
[‡] ASC, alternative specific constant
[§] Standard errors are given in parentheses ()
[††] The attributes DAY and USAGE are effects coded. The coefficient of the omitted attribute levels “day 1” and “waste” can be obtained by calculating the negative of the sum of the other attribute levels’ coefficients. By definition, no standard errors are obtained.

For classes 2, 3 and 4, statistically significant coefficients for all non-omitted attribute levels can be found. Class 2 (41% of the sample) is named “the ethicists”. This class is price sensitive and the preferences for the different levels of the attribute DAY indicate a discriminating view on the in ovo technique. While in ovo gender determination at early stages of embryonic development, namely days

1 and 4, increases choice probability, class 2 disapproves gender determination on day 9. Also chick culling is clearly disapproved by this class. The usage of by-products as pet food or fodder is significantly preferred to the use of screened out eggs in the chemical industry. Wald test reveals that members of this class are indifferent between the former two ($\chi^2 = 2.3$, $df = 1$, $p(> \chi^2) = 0.13$). Members of class 2 also reveal a very high negative parameter for the attribute ERROR RATE. The statistically significant positive coefficient for factor 3 indicates furthermore that class 2 has a higher trust in German livestock production and legal standards, in comparison to class 1.

Class 3 (20% of the sample), called “the technology-savvy” is more price conscious than the other classes. Regarding the attitudes towards in ovo gender determination, all three in ovo alternatives increase choice probability, whereas the attribute level “chick culling” has the opposite effect. The use of by-products as pet food is approved as the best alternative by class 3, whereas respondents disapprove the usage in the chemical industry. The favor of in ovo screening as alternative to chick culling is in line with the statistically significant coefficient for factor 2: in comparison to class 1, class 3 is more favorable towards technological advance in agriculture and for animal welfare improvements.

Class 4 (28% of the sample), named “the eager ones”, is less price sensitive than class 3. Members of class 4 gain positive utility of all proposed in ovo technologies, chick culling is strongly disapproved. The preferences for the attribute USAGE are very similar to class 2, with the utilization of by-products as pet food and fodder preferred over the use in the chemical industry. As in class 2, members of class 4 are characterized by a higher trust in German livestock production and have more confidence in the legal requirements, compared to class 1. This is indicated by the statistically significant positive coefficient for factor 3. It is worth noting that the ASC of class 4 is very high, indicating that members of this class gain a high utility from the alternatives per se and rarely opt-out. They would opt for one of the two alternatives, even if it was described by the least preferred combination of attribute levels. As for classes 2 and 3, also class 4 is significantly disapproving inaccuracy in the gender determination process.

As proven by the LCA, preferences for in ovo gender determination as an alternative to the current practice of chick culling are heterogeneous. A share of 41% of respondents has a differentiated view towards in ovo gender determination, approving it only if it can be carried out with certainty before the onset of pain perception. However, the share which approves in ovo screening independently of these concerns is with 48% similarly high. Also disapproval of chick culling is heterogeneous. While 69% of respondents (classes 2 and 4) disapprove it strongly, 20% of respondents (class 3) might accept chick culling under certain circumstances, as e.g. a low error rate and a meaningful use of male chicks as pet food.

Preferences regarding the usage of by-products - incubated eggs or male chicks - are relatively homogeneous in classes 2, 3 and 4. For all classes, the use as pet food is the preferred alternative, followed by the use as livestock fodder. A surprising result is that using screened out eggs in the chemical industry is disapproved in all classes. Class 3 equally rejects this, as well as if the eggs had to be thrown away. Classes 2 and 4 indicate that “no use” and therefore “waste” of by-products is the worst of the given attribute levels.

Findings allow the calculation of respondents’ WTP for the implementation of in ovo screening (stated in a premium per box of 10 eggs) in comparison to the current practice of chick culling, for classes 2, 3 and 4. For class 1, no statistically significant coefficients are obtained for the levels of the attributes DAY and USAGE; calculation of WTP is therefore meaningless. Marginal WTP for the attribute levels, calculated as the rate of substitution between the attribute levels’ coefficients and the price coefficient, differs between the classes. This can be seen in Figure 1. Class 2 is only slightly price sensitive. Marginal WTP in order to move from the current practice of chick culling to in ovo gender determination is therefore very high, ranging from €8.26 for day 1 to €3.43 for day 9 per box of 10 eggs. Also WTP for a meaningful use of by-products is high for this class: to use by-products in the chemical industry, as pet fodder or livestock feed instead of removing them as “waste”, members of class 2 are willing to pay on average €2.03, €4.55 and €4.05 per box of 10 eggs.

Members of the more price sensitive class 3 are willing to pay on average a premium of €0.42, €0.67 and €0.74 per box of 10 eggs in order to switch from chick culling to in ovo gender determination on days 1, 4 and 9 respectively. To find a solution where eggs or culled chicks can be used meaningfully as pet food, members of this class are willing to pay an additional €0.96 per box of 10 eggs. In contrast, the use in the chemical industry is not considered a viable option by this class.

Class 4 is less price conscious and strongly disapproving chick culling. On average WTP a surplus of €5.77, €5.76 and €4.61 per box of 10 eggs can be found for this class, in order to switch from the current practice to in ovo screening at days 1, 4 and 9. The preferences of class 4 for the levels of the attribute USAGE are very similar to those of class 2, with marginal WTPs for the usages in the chemical industry, as pet food or fodder of €1.55, €3.65 and €3.27 per box of 10 eggs respectively. Price increases of eggs seem to be no barrier for the implementation of the in ovo technology for a majority of respondents (69%). It can be assumed, that the probable price increases per box of 10 eggs will be accepted by this share of the population. However, 20% of the population is shown to be more price sensitive, with WTP under €1.00 per box of 10 eggs in order to switch from chick culling to in ovo screening.

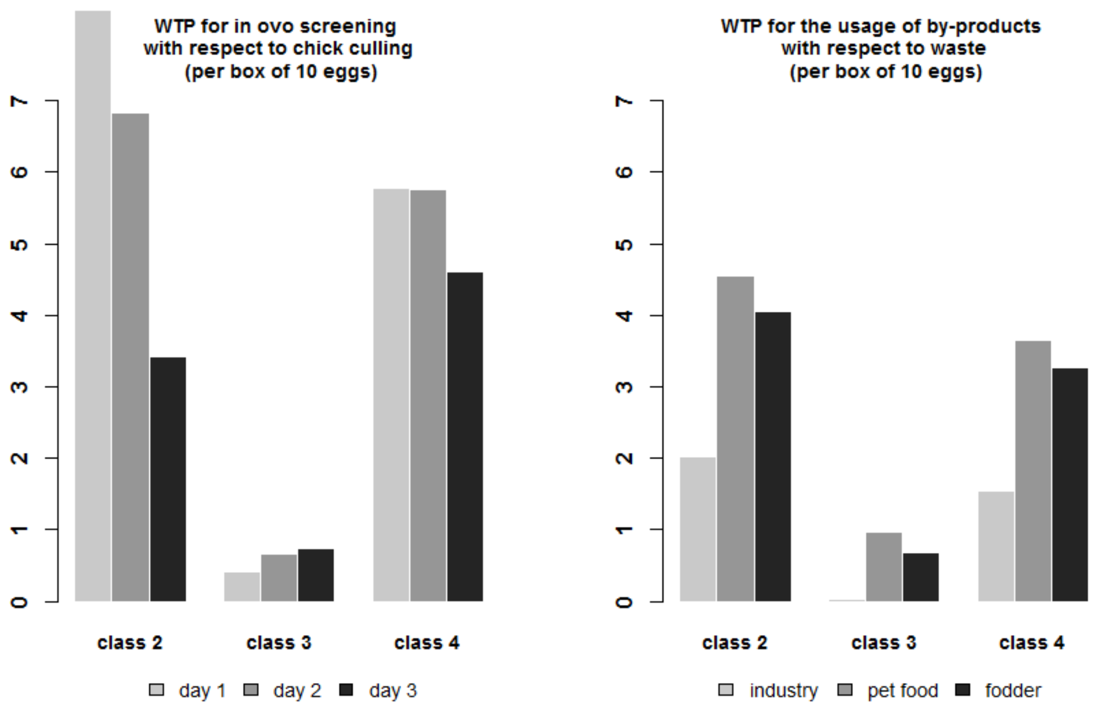

Figure 1 Marginal WTP for the attribute levels of DAY (with respect to chick culling) and USAGE (with respect to waste)

5. Discussion

The culling of layer-type male chicks is publicly criticized due to ethical concerns. Abandoning the practice comes with changes along the production chain. The most promising alternative to be applied on a large scale in the future is in ovo screening of incubated eggs. However, the implementation of in ovo screening may also cause ethical concern and will potentially raise the costs of consumption eggs. To analyze consumer preferences for the implementation of in ovo gender determination, we conducted a survey including a choice experiment with German respondents. Germany is very suitable as a study area because chick culling and its potential alternatives are highly discussed. Findings from this study deliver a comprehensive understanding of societal attitudes towards this new technology, which have not been studied in this detail before.

A LCM is applied on data from a choice experiment conducted with a representative sample of 482 German respondents. This segmentation approach provides insights into the distribution of respondents' attitudes for different characteristics associated with chick culling and in ovo gender determination. Results of the LCM prove that heterogeneity towards the different in ovo technologies and the production characteristics exists. This heterogeneity becomes also apparent in respondents' WTP for certain characteristics of the in ovo technology. Furthermore, all factors received from attitudinal Likert Scale questions through an explorative factor analysis were shown to be meaningful predictors of class assignment and therefore explaining heterogeneity.

Findings show that chick culling is widely disapproved and that maintaining the current practice is considered the worst alternative for the majority of respondents (89%), while in ovo gender determination is preferred. However, choice behavior of 41% of respondents indicates ethical concern about the in ovo technology; it is approved if conducted at a stage of embryonic development, when sentience can be excluded with certainty (days 1 and 4). While 20% of respondents are price sensitive, the study finds a low price sensitivity and high WTP for in ovo screening alternatives for 69% of respondents. However, one class, representing 11% of the sample, indicates to disapprove both chick culling and in ovo screening.

Findings allow a number of implications. There seems to be no one solution for the abandoning of chick culling. In ovo screening is widely accepted, but results indicate that also other alternatives, including the current practice, might be demanded on the market, too. Furthermore, high WTP values indicate that the adoption of in ovo screening could be an interesting option for producers, also besides the current practice of chick culling. This could apply also for countries where chick culling will not be prohibited by law, and where certain consumer segments are willing to pay for enhanced livestock production conditions. In this case, to market eggs labeled as coming from in ovo screened hens could be an attractive option for producers in order to differentiate from the market.

Interestingly, respondents in this sample were willing to pay considerable amounts for a production attribute, which did not render an apparent advantage: the later usage of by products, male chicks or screened out eggs. WTPs for these factors are found to be comparably high, though less than for the attribute DAY. This WTP can be interpreted as willingness for pro-environmental behavior and can be observed for all classes which support in ovo screening as an alternative to chick culling (89% of the sample). The high WTPs should furthermore be understood as an invitation to politicians to consider the legal foundations for a meaningful use of by-products of in ovo screening, as this appears to be a very important point in addition to the day of gender determination. The importance of this production characteristic should not be underestimated when searching for alternatives to chick culling, which are considered ethically superior. In practice, the usage of by-products as male chicks or incubated screened out eggs could be a decisive point when implementing in ovo screening on a large scale.

6. **Conclusion**

In ovo gender determination could be applied at a large scale in the near future, low implementation cost might render it an interesting option also for markets, where the discussion about chick culling is less topical. However, attitudes towards chick culling alternatives were only studied in a few northern European countries so far. There is evidence that cross-cultural differences in attitudes towards farm animal welfare exist (Nocella et al. 2010); therefore investigation of citizens' attitudes towards the alternatives to chick culling in other European or non-European countries should be subject to future research. The case of chick culling opens fields for investigation in order to obtain profound insights into citizens' expectations towards ethically sound agricultural production standards in the context of technological advance.

Besides the specific field of alternatives to chick culling, this study contributes to the literature on ethical evaluation of the slaughter of very young animals, as e.g. the related field of the culling of calves or also the culling of pregnant or unborn livestock. It is worth noting that results are received from a hypothetical choice experiment. Stated WTP estimates can be exposed to hypothetical bias, which might be a reason for the very high WTP estimates. The values obtained in this analysis should be validated through future studies by means of revealed preferences approaches. Nevertheless, findings of the study provide valuable insights into societal attitudes towards the implementation of in ovo gender determination; they give relevant implications for both marketers and political decision makers when looking for an ethically more accepted alternative to chick culling.

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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