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## Farm Animal Welfare—Testing for Market Failure

Fredrik Carlsson, Peter Frykblom, and Carl Johan Lagerkvist

Many consumers are concerned with animal welfare in the conventional production of farm livestock. This concern can be related both to their own and others' consumption. In the latter case, there is a negative externality from consumption. We suggest a survey design that enables us to test for a market failure in farm livestock production. Applying this to the question of battery cages in egg production, we cannot show that a market failure exists. The policy can be extended to a general discussion of how potential market failures for all kind of farm livestock should be managed.

*Key Words:* animal welfare, choice experiments, market failure

*JEL Classifications:* D12, Q13, Q18

The multiple roles of agriculture receive increased attention worldwide. It is generally recognized that agriculture is more than just its primary purpose of producing food, fiber, and other commodities. Considerable attention is now given to the production of positive and negative external effects. The economic effects of agricultural externalities have been estimated in a number of articles (e.g., the pastoral landscape, historical values and nitrogen run-off; see Boyle, Poor, and Taylor; Brunstad, Gaasland, and Vardal; Prückner). It has been suggested that farm animal husbandry could also be a source of external effects (McInerney). The issue of animal welfare is

essentially concerned with people's ethical beliefs. Although philosophy or science-based definitions of animal welfare might differ, they all translate into some commonly used indicators that include animal health, production, physiology, and ethology (Moynagh). Negative externalities of poor treatment of animals can thus relate to any combination of these indicators. These externalities will likely not be valued in the market, which might cause a free good situation to lead to over-exploitation of animal welfare (Bennett 1995). The welfare of farm animals has been a topic of public concern for a relatively long time in Europe, but a number of recent events indicate an increasing interest also in the United States. Prime examples include voters in Florida passing an amendment that prohibits the confinement of pregnant sows in small cages, agreements by fast-food chains to stop buying chickens treated with fluoroquinolone antibiotics, and the enacted legislation in New Jersey calling for humane treatment and sale of domestic livestock.

Although a policy maker can choose from a whole battery of instruments to correct the possible negative external effects of animal

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welfare, the typical response within the European Union (EU) has been the use of regulations (Bennett 1997). Production regulations can increase the provision of desirable product attributes; however, the regulations can also raise production costs. If higher costs are not matched by at least the same magnitude of benefits, the regulation will be detrimental to the welfare of consumers. Furthermore, once regulations are implemented, they are many times difficult to revert because of large economic and political costs. It is important, therefore, to show that a negative external effect exists before any action is undertaken.

Empirical tests of the presence and extent of negative external effects of farm animal husbandry have been conducted in numerous countries, including Australia, Finland, Northern Ireland, Sweden, the United Kingdom (UK), and the United States. Almost all of these studies have been applied to eggs produced by hens kept in battery cages versus free-range production system (see Andersson and Frykblom; Bennett; Bennett and Larson; Rolfo). A significantly higher willingness to pay (WTP) has consistently been found for the presumably more animal-friendly free-range system. For example, with the use of a contingent valuation approach, Bennett and Blaney found support for legislation to phase out the use of battery cages for egg production in the EU using data from a UK survey from 1996.

Our general concern in this study is the design of previous studies. Although previous surveys might not have been designed to accurately measure externalities, we demonstrate how choice experiments can be used to achieve this. A large-scale choice experiment is applied to the question of eggs from battery cage and free-range production systems. We cannot show that a ban of cages in egg production would increase social welfare. Because the results contradict the previous literature, this supports our hypothesis that previous surveys might have overestimated the benefits of a ban in the use of cages. Consequently, the consumers are in this specific case better off with a market solution

in which they are allowed to choose how their eggs are produced.

### Theoretical Model

Improved conditions for farm animals can be beneficial not only to the animals, but also to consumers and producers. For example, improved functioning of the animal's immune system benefits the producer and reduced stress levels and use of antibiotics affects the consumer's perceived quality of meat. Besides perceived changes in food quality, a consumer's utility might also be affected by perceived changes in animal welfare (AW). A number of authors have suggested that modern intensive farm animal production can create negative external effects because of poor AW (see Bennett (1995); Bennett and Larson; McInerney). A detailed and rigorous discussion of different possible definitions of AW can be found in a report prepared by Bennett et al. for the British Ministry of Agriculture, Fisheries, and Food. The authors conclude that the choice of definition depends on scientific background and ethical choices. Previous economic valuation studies have, explicitly or implicitly, relied on a definition by McInerney in which the welfare of animals only is accounted for when human welfare is affected by animal welfare. This is also the typical assumption made in welfare economics. We rely on this human-centered definition in the remainder of the paper. However, it is important to be aware that this ethical perspective clearly has implications for our conclusions.

Following McInerney and Bennett, effects on a consumer's utility as a result of changes in AW can be separated into two parts. The first part, private animal welfare cost (PAWC), is the disutility that a consumer might associate with the conditions under which one's own consumed food was produced. The second part, social animal welfare cost (SAWC), is the disutility the consumer might experience because of others' consumption. Even if you do not consume the animal product yourself, the mere knowledge that others do could create disutility. The PAWC is

a result of one's own consumption, and as such, it can be internalized by the consumer. All internalization requires is an opportunity to choose between similar food commodities produced under different conditions or to opt out in the sense of not buying anything of the particular food commodity. Because SAWC is unaffected by own consumption, it can be seen as an external effect.

Suppose now that we want to investigate whether there is a significant negative externality in battery cage egg production. A comparison of the WTP for eggs from battery cage and free-range systems is not enough because more than the SAWC will differ. A difference in the WTP could be due to a number of factors, such as perceived taste, food safety, and other quality aspects (Rolfe). For the same reason, it is not sufficient to find a significant price premium for a scenario in which battery cages are banned and only free-range systems are allowed. This is, however, the comparison that has been used in previous empirical studies. Even if we are willing to assume that the higher WTP is entirely due to improved animal welfare, this would most likely be a combination of a WTP for a reduction of PAWC and SAWC (Andersson and Frykblom).

To develop the theoretical framework of this study, let us consider three consumption possibilities for the consumer. The consumer can buy eggs produced from (i) battery cage production systems ( $x_1$ ), (ii) free-range systems when battery cages are not banned ( $x_2$ ), and (iii) free-range systems when battery cages are banned ( $x_3$ ). Each of these alternatives is associated with a vector of attributes,  $t_i$  ( $i = 1, 2, 3$ ), that describe the quality of the product and a vector of attributes,  $m_i$ , that describe the PAWC of the product. Each of the alternatives is also associated with a disutility resulting from others' consumption, the SAWC. Following Lancaster, we thus express the utility of consuming a particular good as a function of the attributes of that good (see Hanemann [1999] for a detailed description of this type of model). For notational simplicity, let us assume that only battery cage eggs have a SAWC, denoted,  $s_1$ . These three alternatives

are exclusive, and we do not model the decision on how many eggs to buy; for simplicity, one can assume that they can only be purchased in fixed quantities.<sup>1</sup> The direct utility function is written

$$(1) \quad U(x_1, x_2, x_3, t_1, t_2, t_3, m_1, m_2, m_3, s_1, z),$$

where  $z$  is a numeraire. The individual maximizes the utility function subject to the budget constraint

$$(2) \quad p_1x_1 + p_2x_2 + p_3x_3 + z = y,$$

where  $p_i$  is the price of good  $i$  and  $y$  is the income. The individual can only choose one of the goods, so the conditional indirect utility functions are written (Hanemann 1999) as

$$\begin{aligned} (3) \quad u_1 &= u(x_1, 0, 0, t_1, 0, 0, m_1, 0, 0, s_1, y - p_1x_1) \\ &= v_1(t_1, m_1, s_1, y - p_1x_1), \\ u_2 &= u(0, x_2, 0, 0, t_2, 0, 0, m_2, 0, 0, y - p_2x_2) \\ &= v_2(t_2, m_2, s_1, y - p_2x_2), \\ u_3 &= u(0, 0, x_3, 0, 0, t_3, 0, 0, m_3, 0, y - p_3x_3) \\ &= v_3(t_3, m_3, y - p_3x_3). \end{aligned}$$

If we want to estimate the WTP to eliminate the external effect of battery cages, the relevant comparison is between  $x_2$  and  $x_3$  because  $t_2 = t_3$  and  $m_2 = m_3$ . The only difference between these two cases is the external cost of others' consumption of eggs from battery cage eggs, apart from a possible price difference. A comparison of  $x_1$  and  $x_2$  or  $x_1$  and  $x_3$  would capture aspects other than the SAWC of battery cage eggs. Although these comparisons still can be of interest, it would not give information whether battery cages in egg production is a source of market failure. This line of reasoning is similar to the analysis in Hamilton, Sunding, and Zilberman. They illustrate how preferences for product quality regulations can be derived from preferences for both private and public goods. This is supported in an empirical analysis of the WTP

<sup>1</sup> The exposition is simplified, but not to the extent that it would affect the general implications of this study.

for pesticide-free food and a hypothetical voting for a referendum measure to ban pesticide use in agriculture. However, in their paper, the value of the public good character is not measured on its own (by design). In our empirical analysis, we design the experiment so that we can measure the WTP measures separately. To do this, we need to construct a survey in which respondents evaluate both the private and public good attributes at the same time.

### Testing for the Presence of Market Failure

#### *The Choice of Valuation Method*

A number of valuation studies have been applied to the question of battery cage versus free-range systems, and most have used the contingent valuation method (CVM) to collect responses (see Bennett 1997; Bennett and Larsson; Rolfe). A CVM survey provides the surveyor with a point value estimate of a good with a certain combination of attributes, such as color, shape, free range, etc. It is difficult or expensive to estimate the value of individual product attributes. Each change of an attribute requires either a sequence of scenarios to value or multiple surveys. The latter technique, an experimental design with two identical surveys, in which only the type of free-range production system differs, is used by Andersson and Frykblom. Each additional attribute, however, increases the number of scenarios or surveys to value. The larger the number of attributes of interest is, the less complex is the use of a choice experiment compared with CVM surveys. An alternative to the CVM is the hedonic pricing method, an approach that allows for a valuation of individual attributes. It has the additional benefit of being based on real economic commitments (see, e.g., Yen, Jensen, and Wang). Nevertheless, the approach cannot be used to measure the value of reduced externalities because complementarity is required between the good and the externality.

As a response to the shortcomings of other methods, we use a choice experiment for testing the presence of market failure. In

a choice experiment, individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set. The participants are usually asked to perform a sequence of such choices. Each alternative is described by a number of attributes.<sup>2</sup> This survey method thus allows us to estimate the marginal rate of substitution between different attributes, existing as well as hypothetical. Furthermore, a comparison of the WTP for different attributes within the same survey not only implies a possibility for a theoretically correct test of externalities, it also has the advantage of parallel surveys mentioned above.

#### *The Choice Experiment*

A number of steps were taken to design a questionnaire that was policy relevant, plausible, and meaningful to the respondent. First, industry representatives and academic researchers specializing in poultry and egg production were consulted and involved in the process of developing the questionnaire. This was followed up by focus groups, in which the participants were asked to fill out the questionnaire and write down eventual questions or comments. The focus group participants also took part in a round-table discussion of the questionnaire. The results of these focus groups were returned to the individuals and organizations that participated. This iterative process was repeated three times.

The resulting questionnaire consists of three parts. The first includes questions about the respondent's and the household's habits regarding food consumption. The choice experiment constitutes the second part, and questions regarding the respondent's socioeconomic status composes the third part.

In the introduction to the choice experiment, the purpose of the survey was briefly explained. This was followed by a description of the different attributes. The respondents

<sup>2</sup> For overviews of choice experiments, see Alpizar, Carlsson, and Martinsson and Louviere, Hensher, and Swait.

**Table 1.** Attributes and Levels

Attribute	Level
1. GMO	1.1 Current policy. A producer is allowed to use GMO if it can be shown to be harmless 1.2 A ban on genetically modified fodder
2. Omega-3	2.1 Not enriched with Omega-3 2.2 Enriched with Omega-3
3. Origin	3.1 Produced within the EU, but not in Sweden 3.2 Produced in Sweden
4. Production system	4.1 Produced in a battery cage system 4.2 Produced in a free-range system, battery cages are still allowed 4.3 Produced in a free-range system, battery cages are banned

were also provided with a separate fact sheet providing a description of each of the attributes. The attributes are presented in Table 1, and an example of a choice situation is presented in the Appendix together with the fact sheet that was used; these were of course presented in Swedish to the respondents.

The attribute of interest in this paper is the production system attribute. By comparing the preferences for the three levels of this attribute, we can directly test whether there is a market failure or not. Comparing the WTP to move from eggs produced in a battery cage with eggs produced in a free-range system but in which battery cages are allowed measures the private benefit of consuming eggs produced in a free-range system. The move from eggs produced in a free-range system but in which battery cages are allowed to a case in which battery cages are banned measures the public good character. From this perspective, a ban on battery cages would be justified only if the latter comparison shows a significant positive difference in WTP. Note that in the experiment, the respondent can, by construction, affect the choice sets of others. By choosing a specific alternative, battery cages are banned. This is obviously not how choices in the real market are made. However, because we wanted to disentangle the values, this type of design was necessary. Our experience from pilot studies and focus groups is that respondents understand the choice they have to make. However, that is not the same as saying that their behavior would be the

same in, for example, a referendum vote on a ban. For example, a referendum vote might trigger a different set of preferences than would a choice experiment between food products.<sup>3</sup>

In the choice experiment, each respondent answered three choice sets. In each set, they were asked to choose between three alternatives: one opt-out alternative and two generic alternatives. In the opt-out alternative, all attributes were set to the first level in Table 1, and the price was the same as the current price for a half dozen battery cage eggs, approximately 7 Swedish Krona (SEK 7).<sup>4</sup> The attribute levels were varied independently in the two other alternatives, with no specific alternative labeling of these two.

The choice sets were created with the use of a cyclical design principle (Bunch, Louviere, and Andersson). A cyclical design is a straightforward extension of the orthogonal approach. First, each of the alternatives from a fractional factorial design is allocated to different choice sets. Attributes of the additional alternatives are then constructed by cyclically adding alternatives into the choice

<sup>3</sup> See, for example, Nyborg for an interesting discussion on the possibility of multiple preference orderings, personal well-being functions, and subjective social welfare functions. Our hypothesis would thus be that it is more likely that our respondents, if they have multiple preference orderings, would use the personal well-being function when responding to our choice experiment.

<sup>4</sup> At the time of the experiment, US\$1 = SEK 10.

set on the basis of the attribute levels. The attribute level in the new alternative is the next higher attribute level to that applied in the previous alternative. If the highest level is attained, the attribute level is set to its lowest level. These two alternatives are then compared with a constant base alternative in each choice set. In total, 12 choice sets were created. These were then blocked into four different survey versions.

The hypothetical nature of the experiment might induce respondents to exaggerate their stated WTP, meaning that our estimated levels of the marginal WTP could be overestimated. Both Carlsson and Martinsson and Cameron et al. failed to reject a hypothesis of equal marginal WTP in a real and a hypothetical setting, whereas Johansson-Stenman and Svedsäter rejected the equality of marginal WTPs, and Lusk and Schroeder found that hypothetical choices overestimate total WTP but did not reject the equality of marginal WTP for changes in individual attributes. In a well-known paper by Carson, Groves, and Machina, the incentive properties of various stated preference methods are analyzed. Their conclusion is that hypothetical bias is not of major concern for marginal WTP for private goods. However, even if there is a hypothetical bias in marginal WTP, our main interest is in the relative magnitude of the estimated WTP for the two free-range attributes. One might assume that the potential biases do not differ systematically among the attribute levels. Consequently, a comparison between two attribute levels is less vulnerable to the hypothetical nature of choice experiments.

#### Economic and Econometric Specification

Assuming a linear indirect utility function, the utility of alternative  $i$  in choice situation  $t$  for individual  $k$  is

$$(4) \quad V_{itk} = \beta' a_{it} + \lambda(y_k - price_{it}) + \varepsilon_{itk},$$

where  $a_i$  is the attribute vector,  $\beta$  is the corresponding parameter vector,  $y_k$  is income,  $price_{it}$  is the price of alternative  $i$ , and  $\varepsilon_{itk}$  is an

error term. The attribute vector contains all the attributes of the choice experiment, including the egg attribute discussed in the theoretical model. From this specification, the mean marginal WTP for a certain attribute is the ratio of the attribute coefficient and the cost coefficient,  $\lambda$  (Hanemann 1984).<sup>5</sup>

The probability that individual  $k$  will choose alternative  $i$  can be expressed as

$$(5) \quad P_{itk} = P[\beta' a_{it} + \lambda(y_k - price_{it}) + \varepsilon_{itk} > \beta' a_{jt} + \lambda(y_k - price_{jt}) + \varepsilon_{jtk}; \forall j \neq i].$$

In the analysis of the responses, a random parameter logit model is applied. In such a model, taste variation among individuals is explicitly treated (see, e.g., Train 1998, 2003). A random parameter logit model is a generalization of a standard multinomial logit. The advantages of a random parameter logit model are that (i) the alternatives are not independent (i.e., the model does not exhibit the independence of irrelevant alternatives property) and (ii) there is an explicit account for unobserved heterogeneity. However, an application of a random parameter model is not straightforward because decisions about which parameters are to be random and the distribution of the random parameters have to be made. Because the main purpose is to estimate marginal WTP, the cost attribute is kept fixed, mainly because then the distribution of the marginal WTP for an attribute is the distribution of the attribute. Furthermore, to restrict the coefficient so that the cost attribute is nonpositive for all respondents, a normal distribution is not recommended. A lognormal distribution, which would restrict the sign of the variable, can result in extremely high WTP estimates because values of the cost coefficient close to zero are possible (Revelt and Train). To determine which attribute coefficient to treat as random, a test proposed in McFadden and Train is applied. With this test, artificial variables are constructed from a standard logit estimation,

<sup>5</sup> When the model is estimated, the income variable drops out because only differences in utility affect the choice probabilities.



$$(6) \quad w_{it} = \left( a_{it} - \sum_{j \in C} a_{jt} P_{jt} \right)^2,$$

where  $P_{jt}$  is the conditional logit probability and  $C$  is the choice set. The logit model is then re-estimated with these artificial variables, and the test of whether a coefficient should be fixed or not is based on significance ( $t$ -test) of the artificial variable  $w_{it}$  that corresponds to the coefficient (see McFadden and Train). Applying this test to our data, we find that only the intercept should be randomly distributed: the estimated model is thus a random effects model. Finally, a specific distribution of the randomly distributed intercept needs to be specified. Because there is no reason to restrict the coefficient to be nonnegative, a log-normal distribution can be ruled out. Three other distributions are available in Limdep 8.0: a normal, a triangular, and a uniform distribution. The choice between these three distributions does not seem to be as critical as the choice between these or a log-normal distribution (Hensher and Greene), and this is also the case with our data. One simple approach for receiving some guidance on the choice of distribution is presented in Hensher and Greene. With this approach, the standard logit model is estimated  $N$  times, with  $N - 1$  respondents, where  $N$  is the total number of respondents. So for each estimation, one individual is removed from the sample. A visual inspection of a plot of the  $N$  coefficient estimates for each attribute will then reveal information about the distribution of the unobserved heterogeneity. One way of analyzing the coefficient vector is to use a kernel density estimator (Hensher and Greene). Figure 1 reports the results of the kernel density estimator with a logit kernel for the intercept.

From Figure 1, it is seen that a log-normal and uniform distribution can be ruled out. The distribution resembles more a triangular than a normal distribution, so it is assumed that the intercept has a triangular distribution with mean  $b$  and spread  $c$ . Therefore, the density starts at  $b - c$  and ends at  $b + c$ .

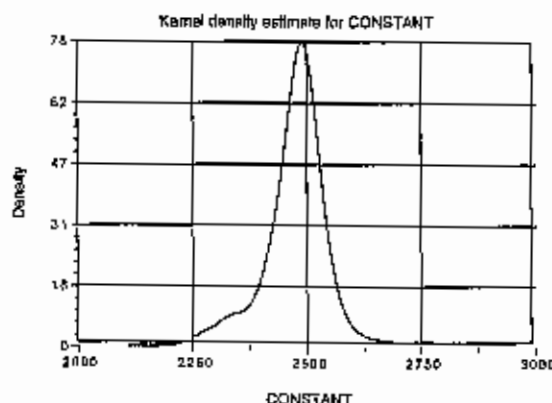


Figure 1. Kernel Density Estimate

## Results

The population that the sample was drawn from was defined as those between 18 and 75 years with a permanent address in Sweden. A random sample of 800 individuals was selected from the Swedish census registry. A mail survey was conducted in October 2002, two reminders were sent out within a 2-week interval to those that had not replied. In total 461 (58%) individuals returned the questionnaire, of which only 450 were available for analysis because of nonresponses to various questions. Not all of these answered all three choice sets; however, we still include these individuals in our estimations. In Table 2, the descriptive statistics of the sample used in the estimations are presented.

The random parameter logit model is estimated with Limdep 8.0. The model is estimated with simulated maximum likelihood with the use of Halton draws with 250 replications. Train (2003) provides details on simulated maximum likelihood and Halton draws. We also include a set of socioeconomic characteristics. These are interacted with the randomly distributed constant. The information of repeated choices is used in the estimations by letting the random parameter vary across individuals, but keeping it constant across the choice situations for each individual. The underlying assumption is of stable preference structures for all individuals (Train 1998). The results of the random parameter logit model are presented in



**Table 2.** Descriptive Statistics Observations Included in Final Estimations

Variable	Description	Mean	SD	Minimum	Maximum
Female	=1 if respondent is female	0.509	0.500	0	1
Age	Respondent's age	46.39	14.82	20	86
Kids	=1 if at least one household member is under age of 20 years	0.369	0.483	0	1
Family size	Number of household members	2.553	1.236	1	8
Responsible for food purchase	=1 if respondent is mainly responsible for food purchase in household	0.420	0.494	0	1
Responses in choice experiment	Number				
Alt 1. Opt out		82			
Alt 2.		582			

Table 3. as is a comparison the results of a standard multinomial logit model.

The random parameter logit model has a substantially higher pseudo- $R^2$  than the standard multinomial logit model. At the same time, there are a few differences between the two models in terms of sign and significance of the parameter estimates. All the attributes included in the choice experiment are significant. Note that the coefficients can

only be interpreted in terms of the sign and the relative size. The specific constant for the opt-out alternative is negative, implying that, all else equal, respondents prefer one of the new alternatives. The spread of the triangular distribution of the constant, though, is large. The estimated coefficients of the attributes are large relative to the size of the cost parameter. This, taken together with the size and sign of the constant, indicates that respondents by

**Table 3.** Multinomial and Random Parameter Estimates

	Multinomial Logit		Random Parameter Logit	
	Coefficient	p-Value	Coefficient	p-Value
Fixed parameters				
Constant: opt out	-0.1783	.725		
Cost	-0.0737	.003		
1.2 No genetic modification	0.2328	.004	0.2519	.006
2.2 Omega-3 in fodder	0.2215	.008	0.2153	.017
3.2 Swedish	1.7243	.000	1.7896	.000
4.2 Free-range legal	0.9031	.000	0.9930	.000
4.3 Free-range market	0.6949	.000	0.7692	.000
Random parameter				
Constant: opt out			-4.9761	.026
Spread of parameter distribution				
Constant: opt out			13.503	.000
Socioeconomic characteristics/heterogeneity in means				
Female	-1.3234	.000	-3.5594	.003
Age	-0.0026	.711	-0.0281	.438
Kids	-1.3887	.002	-3.8694	.021
Family size	0.2540	.086	0.8513	.132
Responsible for food purchase in household	0.8360	.002	2.0119	.050
Log likelihood	770.75		695.95	
Pseudo- $R^2$	0.29		0.48	

**Table 4.** Marginal Willingness to Pay and 95% Confidence Intervals

	Marginal Willingness to Pay (SEK/half dozen)
Free-range legal (Battery cages are banned)	10.84 (6.4–23.0)
Free-range market (Both types of eggs are marketed)	8.40 (4.6–17.5)
Difference in marginal WTP (Free-range legal–free-range market)	2.44 (–0.4–7.3)

large prefer the improved alternatives. This can also be seen from the descriptive statistics in Table 2.

The marginal WTP is the ratio of the attribute coefficient and the cost coefficient. The marginal WTP for the free-range attribute and the difference in WTP between the two attribute levels are presented in Table 4, together with the corresponding 95% confidence intervals. The confidence intervals are based on standard errors estimated with the Krinsky-Robb method (Krinsky and Robb) with 1,000 replications, which means that the confidence intervals are not necessarily symmetric.

The estimated WTP for the two production alternatives are high: the current market price premium is around \$0.50 for a half dozen eggs from a free-range system. Similar to the previous literature, we do find a significant WTP for eggs produced in a free-range system when cages are banned. As pointed out earlier, this is not a sufficient reason for a ban of cages. The relevant comparison is between the WTP for the two types of free-range eggs. This reveals a lower WTP for the market solution than for the regulation solution, and the difference in WTP is nonnegligible. However, we need to test whether the difference is statistically significant or not. If we use the estimated standard errors obtained with the Krinsky-Robb method, we see that we cannot reject the hypothesis of equal marginal WTP. We also apply the complete combinatorial test suggested by Poe, Giraud, and Loomis. This is a nonparametric test that involves comparing differences in marginal WTP for all possible combinations of the estimates obtained by the Krinsky-Robb method (i.e., in our cases, this implies 1,000,000 differences). For all these

differences, they are positive in only 72% of the cases and, thus, negative in 28% of the cases. Consequently, we cannot reject the hypothesis of equal marginal WTP by this test either. On the basis of these results, we can therefore not say that a ban of battery cages would reduce negative external effects from egg production.

#### Discussion and Conclusion

Our food becomes increasingly heterogeneous as public demand has resulted in alternatives such as organic and locally produced goods. Some of these goods are a response to concerns over conventional production of farm livestock. The debate over farm animals has so far been relatively more intensive in Australia and Europe, but there are also increased concerns in the United States. If there are negative externalities in the way farm animals are treated, there are arguments for imposing restrictions in production. Before any kind of policy instrument is implemented though, it needs to be empirically tested as to whether a negative externality actually exists. If no such externality can be found, the economically efficient policy is to have the consumers make the trade-off between different products and prices.

We argue that previous studies have not been able to measure the negative externality of farm animal welfare in a proper way. We use a choice experiment with a design in which the external effect is isolated. Applying it to the question of battery cages versus free-range systems in egg production, we find that there is a difference in the WTP between the market and regulation solution. The difference, however, is not significant and does not justify

a ban of battery cage production. The wider policy implications are applicable not only to the question of egg production. They can be extended to a general discussion of how potential market failures for all types of farm livestock should be managed.

A possible explanation of our results can be found in a hypothesis by Hamilton, Sunding, and Zilberman. They argue that preferences for public goods also can include an aversion against a loss of options. Our results would then measure the net effect of the eliminated externality and the loss of an option value. Their hypothesis does not change any of the conclusions or implications, though, because a ban inevitably results in a loss of options.

A general critique of the use of consumers to determine livestock management is that they are not the only ones to have preferences over the welfare of animals. Individuals might have chosen to not consume livestock commodities for a number of reasons, including because of ethical concerns. Because our survey has not considered this group of individuals, we might have underestimated the benefits of a ban. This is a testable empirical question not unique to this survey; it is applicable to all previously published empirical economic work surveying consumers' demand for animal welfare improvements. It is definitely a question that deserves future attention.

Further empirical and theoretical work to investigate the robustness of our results is warranted. For example, what are the implications of the use of mean values when individuals can be expected to have heterogeneous preferences and endowments? How does information affect the acceptance of an increasingly more heterogeneous food market? We leave these and other questions to future work.

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## References

- Alpizar, F., F. Carlsson, and P. Martinsson. "Using Choice Experiments for Non-Market Valuation." *Economic Issues* 8(2003):83-110.
- Andersson, J., and P. Frykblom. "Exploring Non-market Values for the Social Impact of Farm Animal Legislation." Working paper Series 1999:2. Swedish University of Agricultural Sciences, Department of Economics, 1992.
- Bennett, R.M. "The Value of Farm Animal Welfare." *Journal of Agricultural Economics* 46(1995):46-60.
- . "Farm animal welfare and food policy." *Food Policy* 22(1997):281-88.
- Bennett, R.M., and R.J.P. Blaney. "Estimating the Benefits of Farm Animal Welfare Legislation Using the Contingent Valuation Method." *Agricultural Economics* 29(2003):85-98.
- Bennett, R.M., and D. Larson. "Contingent Valuation of the Perceived Benefits of Farm Animal Welfare Legislation: An Exploratory Survey." *Journal of Agricultural Economics* 47(1996):224-35.
- Bennett, R.M., S. Henson, G. Harper, R. Blaney, and K. Preibisch. *Economic Evaluation of Farm Animal Welfare Policy: Baseline Study and Framework Development—Final Report to the Ministry of Agriculture, Fisheries and Food Location: The Department of Agricultural and Food Economics, University of Reading*. 2000.
- Boyle, K.J., P.J. Poor, and L.O. Taylor. "Estimating the Demand for Protecting Freshwater Lakes from Eutrophication." *American Journal of Agricultural Economics* 81(1999):1118-22.
- Brunstad, R.J., I. Gaasland, and E. Vardal. "Agricultural Production and the Optimal Level of Landscape Preservation." *Land Economics* 75(1999):538-46.
- Bunch, D., J. Louviere, and D. Andersson. "A Comparison of Experimental Design Strategies for Choice-Based Conjoint Analysis with Generic-Attribute Multinomial Logit Models." Working Paper, Graduate School of Management, University of California, Davis, 1996.
- Cameron, T., G. Poe, R. Ether, and W. Schulze. "Alternative Nonmarket Value-Elicitation Methods: Are Revealed and Stated Preferences the Same?" *Journal of Environmental Economics and Management* 44(2002):391-421.
- Carlsson, F., and P. Martinsson. "Do Hypothetical and Actual Marginal Willingness to Pay Differ in Choice Experiments?" *Journal of Environmental Economics and Management* 41(2001):179-92.
- Carson, R., R. Groves, and M. Machina. "Incentive and Informational Properties of Preference Questions." Paper presented at the European Association of Environmental and Resource Economists (EAERE) Ninth Annual Conference, Oslo, 1999.

- Hamilton, S.F., D.L. Sunding, and D. Zilberman. "Public Goods and the Value of Product Quality Regulations: The Case of Food Safety." *Journal of Public Economics* 87(2003):799-817.
- Hanemann, M. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses." *American Journal of Agricultural Economics* 66(1984):332-41.
- . "Welfare Analysis with Discrete Choice Models." *Valuing Recreation and the Environment*. J.A. Herges and C.L. Kling, eds. Cheltenham, UK: Edward Elgar, 1999.
- Hensher, D., and W. Greene. "The Mixed Logit Model: The State of Practice." *Transportation* 30(2003):133-76.
- Johansson-Stenman, O., and H. Svedsäter. "Self-Image and Choice Experiments: Hypothetical and Actual Willingness to Pay." Working Paper No. 94, Department of Economics, Göteborg University, 2003.
- Krinsky, I., and A. Robb. "On Approximating the Statistical Properties of Elasticities." *Review of Economics and Statistics* 68(1986):715-19.
- Lancaster, K. "A New Approach to Consumer Theory." *Journal of Political Economy* 74(1966):132-57.
- Louvière, J., D. Hensher, and J. Swait. *Stated Choice Methods*. Cambridge: Cambridge University Press, 2000.
- Lusk, J.L., and T.C. Schroeder. "Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks." *American Journal of Agricultural Economics* 86(2004):467-82.
- McFadden, D., and K. Train. "Mixed MNL Models for Discrete Response." *Journal of Applied Econometrics* 15(2000):447-70.
- McInerney, J.P. "Animal Welfare: An Economic Perspective." *Valuing Farm Animal Welfare*. Proceedings of a Workshop held at University of Reading, Reading, UK: The University of Reading, 1993.
- Moynagh, J. "EU Regulation and Consumer Demand for Animal Welfare." *AgBioForum* 3(2000):107-14.
- Nyborg, K. "Homo Economicus and Homo Politicus: Interpretation and Aggregation of Environmental Values." *Journal of Economic Behavior and Organization* 42(2000):305-22.
- Poe, G., K. Giraud, and J. Loomis. "Computational Methods for Measuring the Difference of Empirical Distributions." *American Journal of Agricultural Economics* 87(2005):353-65.
- Prückner, G.J. "Agricultural Landscape Cultivation in Austria: An Application of the CVM." *European Review of Agricultural Economics* 22(1995):173-90.
- Revelt, D., and K. Train. "Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level." *Review of Economics and Statistics* 80(1998):647-57.
- Rolfe, J. "Ethical Rules and the Demand for Free Range Eggs." *Economic Analysis and Policy* 2(1999):187-206.
- Train, K. "Recreation Demand Models with Taste Differences over People." *Land Economics* 74(1998):230-39.
- . *Discrete Choice Methods with Simulation*. New York: Cambridge University Press, 2003.
- Yen, S.T., H.T. Jensen, and Q. Wang. "Cholesterol Information and Egg Consumption in the US: A Nonnormal and Heteroscedastic Double-Hurdle Model." *European Review of Agricultural Economics* 3(1996):343-56.

**Appendix. Example of a Choice Situation and the Fact Sheet**

Before you chose any alternatives, you should now read the fact sheet.

Attribute	Choice 1, Eggs		
	Egg 1 (Base Alternative)	Egg 2	Egg 3
<i>Fodder</i>	The fodder fulfills current policy	The fodder fulfills current policy	Guarantee of no GMO in fodder
<i>Animal husbandry</i>	Battery cage	All eggs produced by hen in free-range systems	Your eggs are produced by hen in free-range systems, although battery cages are still allowed
<i>Omega-3</i>	The eggs are not Omega-3-enriched	The eggs are Omega-3-enriched	The eggs are Omega-3-enriched
<i>Country of origin</i>	EU country other than Sweden	EU country other than Sweden	Sweden
Additional cost SEK/half dozen (total cost)	SEK 0 (SEK 7)	+SEK 3 (SEK 10)	+SEK 1.50 (SEK 8.50)
Your choice (mark one alternative)			

Note: GMO is genetically modified organism.

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### Fact Sheet Egg (translated from Swedish)

*To facilitate your choices, we briefly describe the egg attributes.*

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#### 1. Fodder:

According to the policy of the Swedish Meat Industry Association, genetically modified fodder can be used if it can be shown that it is not harmful for humans or animals, does not reduce the biological or genetic diversity, and does not survive or reproduce in other respects than intended.

Possible alternatives are:

- The fodder fulfills current policy, which means that genetically modified fodder can be used. There is no obligation to inform about this.
- The use of genetically modified fodder is banned.

#### 2. Animal Husbandry:

Today consumers can choose between eggs produced in various ways.

- Modern battery cages require a space of 0.06 m<sup>2</sup>/hen, which roughly corresponds to the size of this paper. The size is sufficient to allow natural behavior such as sand bathing, laying eggs in a nest, and sitting on a perch. The limited space does, however, result in weakened skeleton and muscles.
- In low-intensity floor systems (indoor), the hen can move freely on the floor, hence the name "free-range hen". Each hen has at least 0.11 m<sup>2</sup> at its disposal, including perches and nests. Compared with a cage system, the risk of parasites, cannibalism, and feather pecking is higher.

Possible alternatives are:

- The eggs you buy are produced by hens in battery cages.
  - The eggs you buy are produced by hens in free-range systems, although battery cages are still allowed.
- 

#### 3. Omega-3:

Eggs can be Omega-3-enriched. Omega-3 is a polyunsaturated fatty acid. It lowers the blood pressure and reduces the risk for heart and vascular disorders. Fish, walnuts, soybeans, and linseed all contain Omega-3 naturally. By feeding the hen linseed, eggs will contain Omega-3.

Possible alternatives are:

- The eggs are not Omega-3-enriched.
- The eggs are Omega-3-enriched.

#### 4. Country of Origin:

Apart from concerns for animal well-being and quality aspects, country of origin can be a decisive factor in buying decisions.

Possible alternatives are:

- The eggs are produced within the EU but not in Sweden.
- The eggs are produced in Sweden.