AKF Working paper

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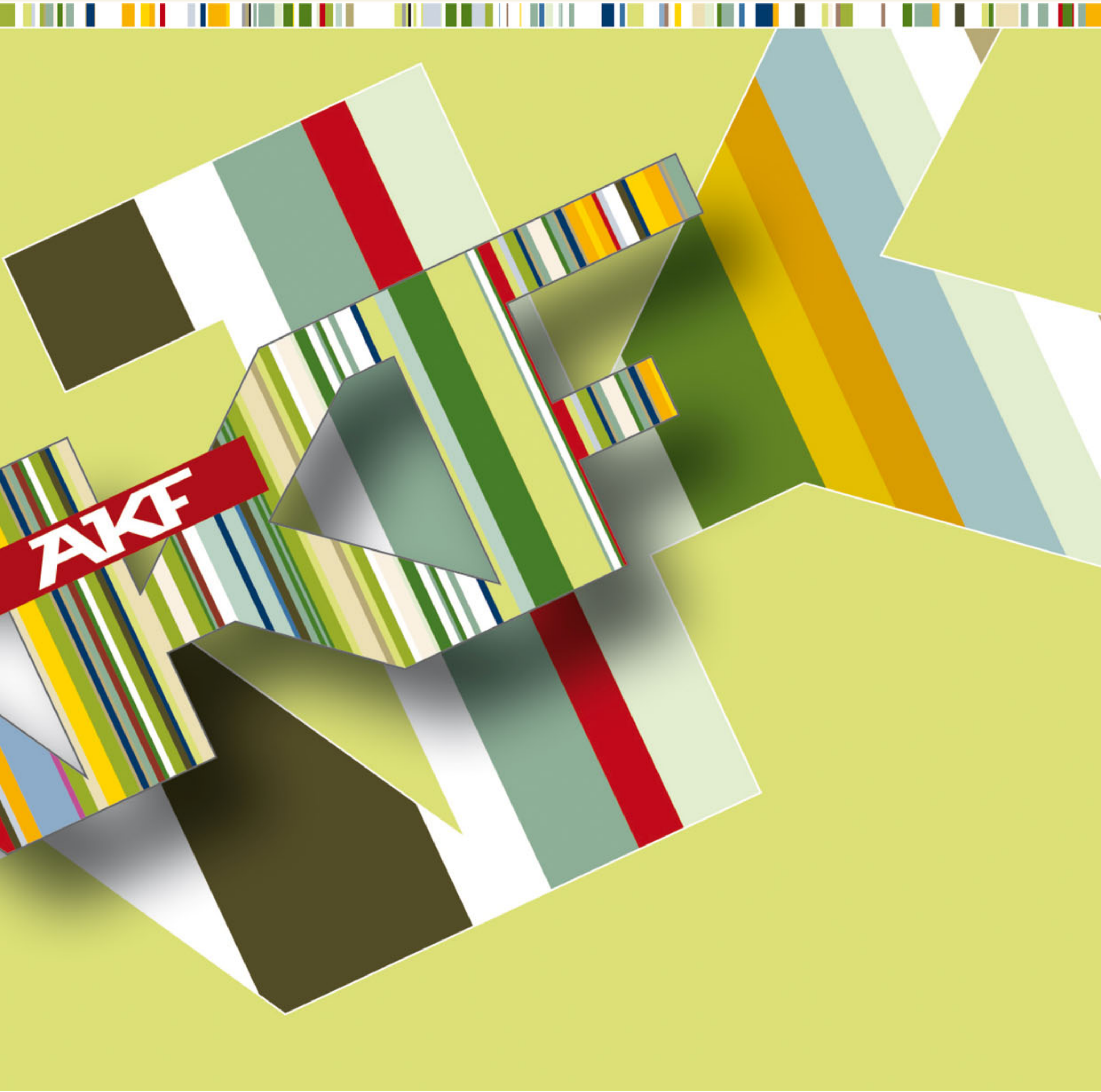
Animal Welfare and Eggs

– Cheap Talk or Money on the Counter?



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Contents

Abstract

In this paper we utilise a unique combination of household level real purchase panel data and survey data on perceived public and private good attributes of different types of eggs to identify real willingness to pay for animal welfare using a mixed logit model. We find that consumers perceiving a stronger connection between animal welfare and the organic label have higher willingness to pay for organic eggs when we control for private good attributes such as food safety also connected to the label. Our results suggest that altruistic motives may play an important role in the demand for agricultural products.

Key words: Animal welfare, MMNL, market data, labelling, willingness to pay, altruism

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1 Introduction

Do consumers really care about animal welfare, and are they willing to pay for increased animal welfare? The results in this paper suggest that consumers are willing to put money on the counter, and that the stated willingness to pay observed in opinion polls, hypothetical discrete choice experiments or contingent valuation studies is not just cheap talk.

According to the Eurobarometer Survey conducted in the beginning of 2005, 74% of European citizens believe that they can to some degree have a positive impact on the welfare of farm animals by buying animal-friendly products, and more than 60% state that they are willing to pay an additional price premium in order to do so (Eurobarometer 2005). The aim of this paper is to estimate actual willingness to pay from observed purchases, in order to separate actual willingness to pay from cheap talk.

Interest in animal welfare has been increasing, both within the population in general and among the legislators who try to frame laws to match these new concerns. One example of this concern is the EU Action Plan to improve animal welfare (IP/05/698), which was adopted by the European Union in 2006. If society wishes to improve the level of animal welfare it may either prohibit production methods that lead to unacceptably low levels of animal welfare or it may improve market conditions for producers who use more animal-friendly production methods. Provision of information using labelling allows the more dedicated producers to signal that their production has a higher level of animal welfare than the standard production. Thereby, labelling offers a way of allowing consumers who actually gain utility from improved animal welfare to achieve this increase in utility without decreasing the utility of less caring consumers. The labelling of eggs described in section 2 is aimed at improving animal welfare.

However, since it is not possible to exclude others from enjoying the improved animal welfare induced by one's own purchase of a certified product this attribute is a public good, and therefore prone to free-riding which might undermine the effectiveness of labelling schemes. This potential problem has been addressed in two strands of literature both suggesting that there is a willingness to pay for animal welfare despite the potential free rider problem. First of all, a number of contingent valuation studies (such as Rolfe (1999) and Bennet (1997)) find a positive stated willingness to pay for eggs with improved animal welfare. Though encouraging, these studies cannot distinguish real willingness to pay from cheap talk and there is a lingering suspicion that when consumers are put to the real market test free-riding kicks in.

Other studies such as Teisl et al. (2002) and Baltzer (2002) use market data. Both studies find positive (revealed) willingness to pay for animal welfare. Teisl et al. find positive willingness to pay for a label indicating dolphin-safe tuna catching, and Baltzer finds positive willingness to pay for eggs carrying labels indicating improved animal welfare (non-battery eggs, see below).

However, the suspicion here is that other ‘private good’ attributes like healthiness/safety of the product that consumers perceive as correlated with animal welfare may be driving behaviour.

Though the previous literature suggests this to be the case it is still not clear that consumers are willing to pay higher market prices for increased animal welfare even though it is a public good. The aim of this paper is to estimate actual willingness to pay for the animal welfare attribute from observed purchases. We utilise a unique dataset combining time series of actual purchase data for 2000 households with survey data on the same households with background information about the individual households along with information on the household perception of the organic label with respect to animal welfare and food safety. This allows us to compare willingness to pay between different socio-demographic groups as well as between groups with different perceptions of animal welfare in relation to organic eggs and food safety in relation to organic broilers. This means that we can establish whether the willingness to pay originates solely from ‘private good’ attributes, such as lower risk of falling ill, or if there is also willingness to pay for ‘public good’ attributes like animal welfare implying altruistic motives.

The results in this paper suggest that consumers are willing to put money on the counter for animal welfare, and that the stated willingness to pay observed in opinion polls, hypothetical discrete choice experiments or contingent valuation studies is not just cheap talk.

The remainder of this paper is structured as follows. Section 2 presents the main differences between the egg labels applied in Denmark. In section 3 the data are described, while section 4 presents an introduction to the theory behind willingness to pay and the mixed multinomial logit model applied in the estimation of the model. Section 5 describes the practical problems of using market data at household level, and explains the solutions chosen. The results of the estimations are presented in section 6. Section 7 concludes.

2 The Egg Labels

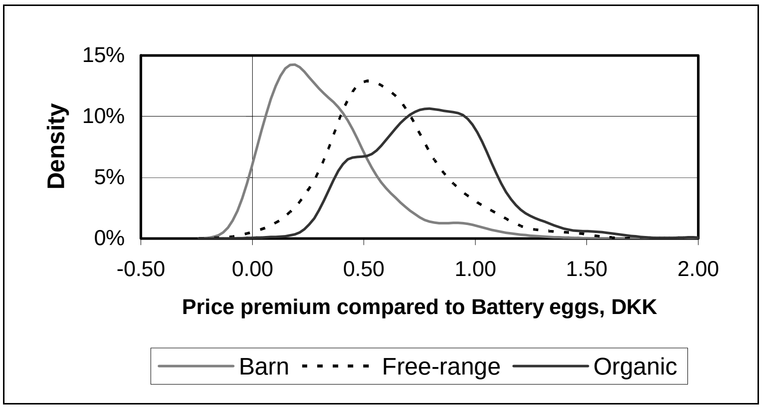
The Danish egg market is dominated by four different labels indicating production methods with different implications for animal welfare. In order to be allowed to bear a given label the production has to meet certain minimum standards, as described in various EU regulations. Table 1 shows the most important differences between the egg labels, and Figure 1 shows the distribution of price premiums compared to the price of battery eggs (the price of a battery egg is close to 1 DKK). For more details of the rules for different production types, see Andersen (2006).

Table 1 Main points of the rules for different production types

Egg label	Conditions for the egg-laying hens
Battery eggs	• Live in cages with 4 hens in each cage • 16 hens per m^2
Barn eggs	• Live in open barns • 7 hens per m^2
Free-range eggs	• Indoors: As for barn hens • Access to outdoor areas • 10 m^2 per hen on outdoor areas
Organic eggs	• 6 hens per m^2 indoors • Access to outdoor areas • 4 m^2 per hen on outdoor areas • Organic feed • No beak trimming

Source: The Danish Poultry Council.

Figure 1 Kernel density of imputed price premiums



Estimations using GfK purchase data on eggs from 26 June 1999 to 30 June 2000. Only households with answers to questionnaire. Nadaraya-Watson kernel regression estimator using the Gaussian kernel. Purchases made directly from farms excluded. Imputed prices are means of all observed prices within a given chain of stores and a given week. More information on this is provided in Section 5, 'Implementation of the model'.

Battery hens are usually considered to have the lowest level of animal welfare, because they are kept in small cages. Barn hens are allowed to move more freely, but do not have access to outdoor areas, and are therefore usually considered to be better off than battery hens, but worse off than free-range and organic hens. One of the differences between organic hens and free-range hens is that free-range hens may have their beaks trimmed, which is known to cause immediate and subsequent pain. The problem is that in extensive egg production systems, the risk of severe welfare problems such as injurious pecking and cannibalism is much greater in non-trimmed hens (ADAS/IGER/University of Bristol, 2001). Whether organic hens have a better quality of life than free-range hens is therefore sometimes debated, but apart from the differences in rules for production, organic eggs have the advantage of using a familiar label that is used on many different food products (the Danish 'Ø-label', which identifies organically-produced goods). Consumers have a generalised image of goods bearing the Ø-label, and do not have to spend time and energy studying new labels such as 'barn eggs' or 'free-range eggs'. In this paper it is therefore expected that willingness to pay for the different egg labels can be ranked as *battery, barn, free-range* and *organic*, where *battery eggs* are expected to yield the lowest willingness to pay and *organic eggs* are expected to yield the highest willingness to pay. As can be seen in Figure 1, the observed prices of the different types of egg support this ranking.

3 Data

The data are from a Danish panel of approximately 2,000 households reporting all food purchases (GfK ConsumerScan Denmark, GfK). The panel is unbalanced and started in 1997. A substantial number of socio-demographics are collected once a year, and in 2002 a large questionnaire on organic food was issued to the panel (AKF/GfK questionnaire, 2002). The purpose of the questionnaire was to obtain information about knowledge of and attitudes towards organic foods in general at household level. It is therefore possible to combine actual purchases with socio-demographics, attitudes and perception of specific organic goods. For more on the GfK data see Andersen (2006).

The data on eggs used in this paper cover the period from 26 June 1999 to 30 June 2000. In the analysis, the observed purchases in the GfK data are combined with the results of the 2002 questionnaire. If perceptions about eggs are assumed to be stable over time, the questionnaire makes it possible to use the information about household perceptions of the level of animal welfare and food safety in organic eggs, even though there is a time gap between the purchase data (1999-2000) and the questionnaire (2002). It is therefore possible not only to estimate willingness to pay for labels, but also to allow for different perceptions of the labels, and thereby for different purchasing motives. Among the 1,834 families who reported purchases of eggs during the period from June 1999 to June 2000, 878 families also answered the 2002 questionnaire, and 844 of these answered the questions used in this paper. As can be seen in Table 2, the households who answered the questionnaire represent the sample almost perfectly, at least as far as the overall distribution on types of eggs is concerned.

Table 2 Aggregate consumption of four different types of eggs

Households:	All	With answers to questionnaire in general	With answers to both animal welfare and food safety
Purchase shares:			
Battery eggs	47	47	47
Barn eggs	17	17	17
Free-range eggs	10	10	10
Organic eggs	27	26	26
Total	*100*	*100*	*100*
No. of purchases	20,676	11,178	10,800
No. of households	1,834	878	844

Source: GfK purchase data on eggs from 26 June 1999 to 30 June 2000. Purchases made directly from farms excluded, see section 5.

Two of the questions in the questionnaire regarded perception of animal welfare related to eggs and food safety related to broilers. As can be seen in Table 3, very few households believe that organic production has a negative impact on animal welfare related to eggs or food safety related to broilers, but a substantial number of households believe it has positive effects. It also appears that trust in better animal welfare and improved food safety are correlated. It is, however, still possible to identify the effects on willingness to pay separately for animal welfare and food safety, as the correlation is not perfect. The answers to the two questions enter separately in the estimation, and the grey cross tabulation in Table 3 is merely included to illustrate the level of correlation. Willingness to pay among households with different perceptions of animal welfare and food safety is measured relative to the groups of households who perceive 'no difference' (control groups).

Table 3 Answers to questionnaire on perception of animal welfare and food safety[1]

No. of households (share of households):		*Total*		How do you perceive the risk of falling ill with bacteria when you eat organic chicken? Higher (Negative organic food safety)		**No difference**		Lower (Positive organic food safety)	
	Total	*844*	*(100%)*	*27*	*(3%)*	***571***	***(68%)***	*246*	*(29%)*
How do you perceive animal welfare for hens laying organic eggs?	Worse (Negative organic animal welfare)	*23*	*(3%)*	6	(1%)	9	(1%)	8	(1%)
	No difference	***355***	***(42%)***	15	(2%)	294	(35%)	46	(5%)
	Better (Positive organic animal welfare)	*466*	*(55%)*	6	(1%)	268	(32%)	192	(23%)

Source: AKF/GfK questionnaire from 2002.

Bold means Control group**:** Willingness to pay in the other groups is measured relative to this group. The estimated willingness to pay for households who perceive animal welfare to be better is the difference between the mean willingness to pay among households with perceived *positive* effect and households with *no* perceived effect.

1 Note that the question about food safety is not related directly to organic eggs, but rather to organic chickens. However, the origin of food-safety problems is the same in chickens and eggs (mainly salmonella during the period in question) and the answers are therefore used as a general indication of perception of food safety related to organic poultry, acknowledging that the signal cannot be expected to be as strong as for animal welfare.

One of the attractions of the GfK data is that it is possible to link actual purchases directly to socio-demographic information about individual households. This paper investigates how income, age, degree of urbanisation and level of education influence the willingness to pay for the different types of eggs. Each of the socio-demographic variables is split into sub-groups, and the willingness to pay within each sub-group is estimated relative to the control group indicated in Table 4.

Table 4 Socio-demographic data used in estimations

Variable	Sub-groups	Number of households	Share of households	Control group[a]
Income[b]	Lowest 25%	254	30	X
	Middle 50%	400	47	
	Highest 25%	190	23	
	Total	*844*	*100*	
Age[c]	18 to 44 years	230	27	
	45 to 59 years	304	36	
	60 years or more	310	37	X
	Total	*844*	*100*	
Degree of urbanisation[d]	Rural municipality	247	29	X
	Urban municipality	390	46	
	Capital area (Copenhagen)	207	25	
	Total	*844*	*100*	
Level of education[e]	No further education stated	206	24	X
	Vocationally oriented high-school	304	36	
	Short further education	138	16	
	Medium further education	150	18	
	Long further education	46	5	
	Total	*844*	*100*	

a: Willingness to pay in the other groups is measured relative to this group. The estimated willingness to pay in the Capital area is the difference between the mean willingness to pay in households in the Capital area and those in the rural municipalities. If the parameter for Capital area is significant, it means that the difference between the utility in the Capital area and that in the rural municipalities is significantly different from zero.

b: Income is recorded in brackets of DKK 50,000 (~ €6,700). These brackets are divided by the number of persons in the household, weighted as 1 for the first adult, 0.5 for the next adults and 0.3 for children. Income is split into three categories indicating relative levels of income.

c: Age is defined by the age of the oldest person in the household.

d: GfK divides the 270 Danish municipalities into categories depending on how urbanised they are and on their geographical location. The geographical location is ignored here, and the sample is split into rural, urban and Capital area municipalities.

e: Highest level of education within the household.

4 Theory

Marginal willingness to pay is the amount of money a person is willing to pay in order to receive an extra unit of the good in question. The utility of household *i* from purchasing type of egg *j* at time *t* is assumed to depend on the label *j* (β_i^j, constant over time, varies with household and type of egg). The vector of labels of the eggs purchased by household *i* at purchase 1 to T_i is called e_i. The utility also depends on the money spent purchasing the egg ($\beta^p p_{jt}$). The price vector *p* is allowed to depend on the egg label and the purchase, but the utility of money β^p is assumed to be constant over time, households and type of egg. The utility is not perfectly observed by the econometrician, and the utility therefore also depends on an unobserved error term ε_{ijt}. This is a Random Utility Model (RUM).

As in Hanemann (1984), the utility function is assumed to have the simple linear form

$$U_i\left(e_i, p\right) = \sum_{t=1}^{T_i}\left(\beta_i^j + \beta^p p_{jt} + \varepsilon_{ijt}\right) \tag{1}$$

and as in Hanemann (1984), the marginal willingness to pay is therefore the utility of the egg divided by the utility of money:

$$wtp_i^j = \frac{\partial U / \partial\left(egg^j\right)}{\partial U / \partial\left(money\right)} = \frac{\beta_i^j}{-\beta^p} \tag{2}$$

The error terms ε_{ijt} in (1) are assumed to be extreme-value distributed, which means that the parameters can be estimated using a multinomial logit model.

However, the conventional multinomial logit model suffers from the assumption of Independence of Irrelevant Alternatives (IIA). In this application, IIA means that the probability of choosing a free-range egg versus the probability of choosing a battery egg should be independent of the presence of, for example, organic eggs on the market. This is very unlikely. Imagine that organic eggs left the market. Then the IIA in the multinomial logit model would imply that people who used to buy organic eggs would distribute themselves across the remainder of the egg labels according to the market share of those other egg labels. But people who buy organic eggs may very well have a higher propensity to buy free-range eggs, for example, than the population in general, and particularly to have a lower propensity to buy battery eggs. IIA is therefore not reasonable in this case.

Data show that some households buy organic eggs more frequently than others, which suggests variation in the household utility of organic eggs. To capture this variation and to avoid

IIA it is therefore assumed that the household utility is drawn from a distribution (i.e. the household utility is known to the household, but only the distribution is observable to the econometrician). The household likelihood function then becomes the likelihood function in the conventional multinomial logit model integrated over all possible values of β:

$$L_i\left(\theta, e_i, p\right) = \int L_i^{conv}\left(\beta, e_i, p\right) f\left(\beta | \theta\right) d\beta \tag{3}$$

where $f\left(\beta|\theta\right)$ is the density of β given the parameters θ. The parameters θ of the distribution of the utility β are therefore estimated, instead of β itself. This is known as the Mixed MultiNomial Logit (MMNL) model (McFadden and Train, 2000). For applications of this model see for example McFadden and Train (2000), Revelt and Train (1998), Train (1998) or Train (1999). The MMNL model does not suffer from IIA, as long as at least one parameter is assumed to be drawn from a common distribution (mixed); see for example Train (1998).

In this paper it is assumed that the utility of the four types of eggs follows a multivariate normal distribution

$$\beta = \begin{bmatrix} \beta^1 \\ \beta^2 \\ \beta^3 \\ \beta^4 \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \end{bmatrix}, \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} \\ \sigma_{12} & \sigma_{22} & \sigma_{23} & \sigma_{24} \\ \sigma_{13} & \sigma_{23} & \sigma_{33} & \sigma_{34} \\ \sigma_{14} & \sigma_{24} & \sigma_{34} & \sigma_{44} \end{bmatrix} \right) \tag{4}$$

where 1 is battery eggs, 2 is barn eggs, 3 is free-range eggs and 4 is organic eggs.

As usual in a discrete model, we can only estimate relative utility, which means that we estimate differences in utility (between types of eggs) and must choose an arbitrary normalisation to identify the scale. In order to estimate willingness to pay for eggs carrying labels indicating higher levels of animal welfare, the differences between the utility of battery eggs $\left(\beta^1\right)$ and the utilities of all other types of eggs $\left(\beta^2, \beta^3, \beta^4\right)$ are estimated.

In the simplest version of the model the utility depends only on the type of egg purchased and the price paid:

$$\begin{aligned} U_i\left(e_i, p\right) - U_i\left(battery, p\right) &= \sum_{t=1}^{T_i}\left(\beta_i^j + \beta^p p_{jt} + \varepsilon_{ijt}\right) - \sum_{t=1}^{T_i}\left(\beta_i^1 + \beta^p p_{1t} + \varepsilon_{i1t}\right) \\ &\equiv \sum_{t=1}^{T_i}\left(\tilde{\beta}_i^j + \beta^p\left(p_{jt} - p_{1t}\right) + \tilde{\varepsilon}_{ijt}\right) \end{aligned} \tag{5}$$

where e_i is the vector of labels of the eggs purchased by household i at purchases 1 to T_i, β^p is the utility of money, β_i^j is the utility of type of egg j for household i, and $\tilde{\beta}_i^j$ is the difference in utility between type *j* and battery eggs. As in the conventional logit, the problem of the scale is solved by normalising the variance of the extreme value distributed error terms (the ε's) to $\pi^2/6$.

The estimated parameters of the distribution of differences in utility are

$$\tilde{\beta} = \begin{bmatrix} \beta^2 - \beta^1 \\ \beta^3 - \beta^1 \\ \beta^4 - \beta^1 \end{bmatrix} = \begin{bmatrix} \tilde{\beta}^2 \\ \tilde{\beta}^3 \\ \tilde{\beta}^4 \end{bmatrix} \sim N\left(\begin{bmatrix} b_{21} \\ b_{31} \\ b_{41} \end{bmatrix}, \begin{bmatrix} \tilde{\sigma}_{22} & \tilde{\sigma}_{23} & \tilde{\sigma}_{24} \\ \tilde{\sigma}_{23} & \tilde{\sigma}_{33} & \tilde{\sigma}_{34} \\ \tilde{\sigma}_{24} & \tilde{\sigma}_{34} & \tilde{\sigma}_{44} \end{bmatrix} \right) \tag{6}$$

Because the utility of each type of egg is assumed to be normally distributed, the differences between the utilities are also normally distributed since $X \sim N(\mu, \Sigma) \Rightarrow \; g(X) \sim N\left(g(\mu), (\nabla g)\Sigma(\nabla g)'\right)$. This means that the relationship between the estimated parameters from (6) and the structural parameters of the utility function (4) is

$$\begin{bmatrix} \beta^2 - \beta^1 \\ \beta^3 - \beta^1 \\ \beta^4 - \beta^1 \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_2 - \mu_1 \\ \mu_3 - \mu_1 \\ \mu_4 - \mu_1 \end{bmatrix}, \begin{bmatrix} \sigma_{22} + \sigma_{11} - 2\sigma_{12} & \sigma_{23} + \sigma_{11} - \sigma_{13} - \sigma_{12} & \sigma_{24} + \sigma_{11} - \sigma_{14} - \sigma_{12} \\ \sigma_{23} + \sigma_{11} - \sigma_{12} - \sigma_{13} & \sigma_{33} + \sigma_{11} - 2\sigma_{13} & \sigma_{34} + \sigma_{11} - \sigma_{14} - \sigma_{13} \\ \sigma_{24} + \sigma_{11} - \sigma_{12} - \sigma_{14} & \sigma_{34} + \sigma_{11} - \sigma_{13} - \sigma_{14} & \sigma_{44} + \sigma_{11} - 2\sigma_{14} \end{bmatrix} \right) \tag{7}$$

It is important to note that the structural parameters are not identified, only the relative parameters in (6). The estimated variances and covariances do not describe the utility of the different types of eggs, but rather the 'utility premium' compared to battery eggs.

In Table 4 and Table 4 the sample was divided into sub-groups on the basis of perception of eggs and socio-demographic factors. Each household belongs to one of the sub-groups for each of the two questionnaire answers and for each of the four socio-demographic variables. The effect of the background variables is estimated non-parametrically by including a dummy for each sub-group. Disregarding the six control groups, the number of dummies is two for perception of animal welfare, two for perception of food safety, two for income, two for age, two for degree of urbanisation and four for education, i.e. a total of 14. See also Table 2 and 4. The simple utility function in (5) then becomes

$$\begin{aligned} & U_i(e_i, p) - U_i(battery, p) = \\ & \sum_{t=1}^{T_i} \left(\beta_i^j + \sum_{k=1}^{14} 1_{[i \in k]} \beta_k^j + \beta^p p_{jt} + \varepsilon_{ijt} \right) - \sum_{t=1}^{T_i} \left(\beta_i^1 + \sum_{k=1}^{14} 1_{[i \in k]} \beta_k^1 + \beta^p p_{1t} + \varepsilon_{i1t} \right) \equiv \\ & \sum_{t=1}^{T_i} \left(\tilde{\beta}_i^j + \sum_{k=1}^{14} 1_{[i \in k]} \tilde{\beta}_k^j + \beta^p \left(p_{jt} - p_{1t} \right) + \tilde{\varepsilon}_{ijt} \right) \end{aligned} \tag{8}$$

where $1_{[i \in k]}$ is an indicator function indicating whether household *i* belongs to socio-demographic group *k*. Note that $\tilde{\beta}_i^j$ is the household-specific utility of type *j* (for the control group). The individual value is drawn from a normal distribution. Only the mean and the standard deviation of the distribution is estimated, not the individual betas. The estimated parameters for socio-demographics therefore describe the *mean* difference between the utility of households in socio-demographic group *k* and the control group. This is illustrated in Figure 3 on page 20.

The utility of barn and free-range eggs is assumed to depend only on socio-demographics. For a household with a high income (inc=H), aged 45 to 59 (age=45-59), living in the Capital area (urb=Cap) and having a long further education (edu=long) the utility of purchasing a barn egg (*j*=2) at time *t* is:[1]

$$U_i\left(organic, p_t\right) - U_i\left(battery, p_t\right) = \tilde{\beta}_i^{barn} + \tilde{\beta}_{inc=H}^{barn} + \tilde{\beta}_{age=45-59}^{barn} + \tilde{\beta}_{urb=Cap}^{barn} + \tilde{\beta}_{edu=long}^{barn} + \beta^p\left(p_{2t} - p_{1t}\right) + \tilde{\varepsilon}_{i2t} \quad (9)$$

As described in table 3 we have answers to questions about perception of animal welfare related to organic eggs and food safety related to organic broilers. This means that we can separate private utility (food safety) from altruistic utility (animal welfare) when it comes to organic eggs. It is therefore possible to determine whether altruistic motives actually play a significant role in the willingness to pay for organic eggs.

It is assumed that the effect of trust in animal welfare or food safety is the same for all socio-demographic groups, and the utility of the public good (animal welfare) and the private good (food safety) is therefore added to the utility function without any interaction terms with socio-demographics. No perceived difference is used as control group. If a household with the same characteristics as in (9) perceives the animal welfare as better for organic eggs and the food safety as worse the utility is therefore modelled as:

$$U_i\left(organic, p_t\right) - U_i\left(battery, p_t\right) = \tilde{\beta}_i^{org} + \tilde{\beta}_{animal+}^{org} + \tilde{\beta}_{safety\div}^{org} + \tilde{\beta}_{inc=H}^{org} + \tilde{\beta}_{age=45-59}^{org} + \tilde{\beta}_{urb=Cap}^{org} + \tilde{\beta}_{edu=long}^{org} + \beta^p\left(p_{4t} - p_{1t}\right) + \tilde{\varepsilon}_{i4t} \quad (10)$$

This definition of the utility function means that the variance of utility is assumed to be the same in all subsets of the population; only the mean is allowed to vary between groups of households.

[1] Note that $\tilde{\beta}_i^{barn}$ is the household-specific utility of barn eggs (for the control group). The individual value is drawn from a normal distribution. Only the mean and the standard deviation of the distribution is estimated, not the individual betas.

5 Implementation of the Model

Only the price of the chosen egg is observed, not the price of the alternatives, nor which alternatives are present in the purchase situation. The prices are therefore imputed as the mean of all observed prices of eggs with a given label within a given week in the chain of stores in which the purchase was actually made.

There are many unknown attributes of the purchased egg. The size of the egg is not recorded, and the store in which the purchase was made is only recorded at chain level. The freshness of the eggs is also unknown. These factors all contribute to unobserved heterogeneity in the prices. Using the observed price as an estimate of the price of the egg that was purchased, and comparing this price to mean prices for the types of eggs that were not purchased (by this household on this occasion) would mean that one was comparing the price of an egg of a given size, purchased in a given store and having a given freshness, with the price of an egg with a mixture of sizes, a mixture of stores and a mixture of different degrees of freshness. This would disturb the estimated effect of the prices, and thereby the estimated effect of the labels and other variables entering the model. It was therefore decided to impute all of the prices, including the price of the egg that was purchased.

The definition of the choice set is also important. It may not be reasonable to expect eggs with all labels to be present in all purchase situations.[2] If eggs with a given label are not present, the label is said to be rationed. If rationing occurs, but is not revealed, it might mean that a person is perceived as choosing not to buy eggs with a specific label even though this label might have been preferred if it had been present. This will lead to a lower estimate of marginal willingness to pay for this label. This is an important fact to keep in mind when interpreting the results of the estimations, especially for barn and free-range eggs that have relatively low purchase shares. In this application, eggs with a specific label are assumed to be rationed if nobody purchased eggs with this label in the relevant group of stores during the week in question.

The mixed multinomial logit models are estimated using a modified version of a programme developed by Kenneth Train, David Revelt and Paul Ruud. This is an extension of the programme used in for example Revelt and Train (1998) and Train (1998). The extension allows estimation of correlations between normally distributed parameters. One of the virtues of this programme is that it takes account of the panel structure of the data. In this paper the simple Halton draws used in the extended programme by Train, Revelt and Ruud are replaced by antithetic Halton draws.

[2] In some purchase situations the labels are not necessarily certified and/or no alternative can be expected to be available. This is e.g. the case for purchases directly from farms. These purchases are therefore excluded from the analysis, along with purchases where the price of battery eggs cannot be imputed.

This practically eliminates the noise in the log-likelihood values of different models, and thereby improves the reliability of the Likelihood Ratio tests.

The utility of money is assumed to be the same for all households, whereas the utility of eggs with different labels is assumed to follow a multivariate normal distribution. This implies that the estimated marginal willingness to pay is also assumed to be normally distributed. In MMNL language this means that the price parameter is fixed, and the reactions to egg labels are mixed. The utility of money is probably not the same for everyone, but in this case it is a question of semantics. It is not possible to tell whether the difference in willingness to pay origins from differences in utility of money or from utility of non-battery labels. The assumption that everyone has the same utility of money whereas the utility of labels is normally distributed is merely a convenient way of assuming that the willingness to pay is normally distributed.

6 Results

First, the model is estimated using only the price and the type of egg as explanatory variables. This version illustrates the results that could be obtained from data with no information on socio-demographics. To illustrate the difference between a conventional and a mixed logit model, the results of a conventional model are compared with a mixed version of the same model. The conventional model is rejected, and information about socio-demographic factors and perception of animal welfare and food safety is then included in the mixed model and the results are discussed.

The mixed multinomial logit estimates a distribution of the mixed parameters. The standard deviation of the normal distribution can be used as a measure of the degree of heterogeneity related to the utility of a given type of egg compared to battery eggs, and thereby also to the degree of heterogeneity of willingness to pay. The estimated correlations indicate the extent to which a high willingness to pay for e.g. organic eggs compared to battery eggs is correlated with a high willingness to pay for other types of eggs compared to battery eggs.

The main hypotheses are:

a) The ranking of willingness to pay for organic, free-range and barn eggs compared to battery eggs follows the animal welfare ranking, which means that willingness to pay is highest for organic eggs and lowest for barn eggs.

b) The correlation between willingness to pay for different types of eggs is highest between organic and free-range eggs, because the production methods are very similar, and lowest between organic and barn eggs (but the correlation is still expected to be positive).

c) The organic label is familiar from other goods and to some people it also includes a health aspect. This means that there are more potential sources of willingness to pay for organic eggs than for free-range and barn eggs, which only differ from battery eggs in terms of animal welfare. (The variance of a sum is the sum of the variances *plus* twice the covariance.) The different sources of willingness to pay are expected to be positively correlated (people who believe that organic products are healthier are more familiar with the organic label). The degree of heterogeneity is therefore expected to be greater for organic eggs than for the other types.

d) Households which perceive animal welfare as better for hens laying organic eggs are willing to pay more for them even when perception of food safety is controlled for (perception of food safety is observed to be positively correlated with perception of animal welfare, but is a private attribute (non-altruistic)).

Table 5 compares the result of the conventional logit with the results of the simplest mixed logit. In all of the estimated models the utility of price is negative and significantly different from zero, which means that the utility of money is positive, as expected. In the conventional logit the ranking of willingness to pay comes directly from the estimated parameters of the utility function. These are all negative, which means that the willingness to pay for non-battery eggs is lower than the willingness to pay for battery eggs. As an example, the willingness to pay for organic eggs compared to battery eggs is $-0.21/-(-0.45) = -0.47$. The conventional logit thus suggests that all households prefer to buy battery eggs unless the organic eggs are DKK 0.47 cheaper. At a first glance this is somewhat contra intuitive, as the price of non-battery eggs is usually higher than the price of battery eggs. But what it actually means is that the price difference is not enough to explain the low purchase shares of non-battery eggs. The logit model therefore estimates negative utility of the labels. The willingness to pay is higher for organic eggs than for barn eggs, as expected, but the willingness to pay for free-range eggs is lower than for barn eggs.

Table 5 Results of estimations based on all households, including only type of egg and price (Model 1)

		Conventional logit			Mixed logit		
		Estimate	SD	Signific.	Estimate	SD	Signific.
Price		-0.45	0.032	***	-0.39	0.122	***
Type of egg, utility relative to utility of battery eggs							
Means:	Organic	-0.21	0.026	***	-1.72	(0.200)	***
	Free-range	-1.17	0.024	***	-1.40	(0.134)	***
	Barn	-0.77	0.013	***	-0.80	(0.094)	***
Variance:	Organic				20.73	(1.819)	***
	Free-range				7.56	(0.706)	***
	Barn				4.31	(0.395)	***
Correlation:	(Organic, free-range)				0.84		
	(Organic, barn)				0.66		
	(Free-range, barn)				0.79		
Log-likelihood		-12,950			-8,385		
No. of households		844			844		
No. of observations		10,800			10,800		

Estimations using GfK purchase data on eggs from 26 June 1999 to 30 June 2000. Purchases made directly from farms excluded. Rationing is allowed. Number of antithetic Halton Draws is 7,500. '***' is significant at the 1% level.

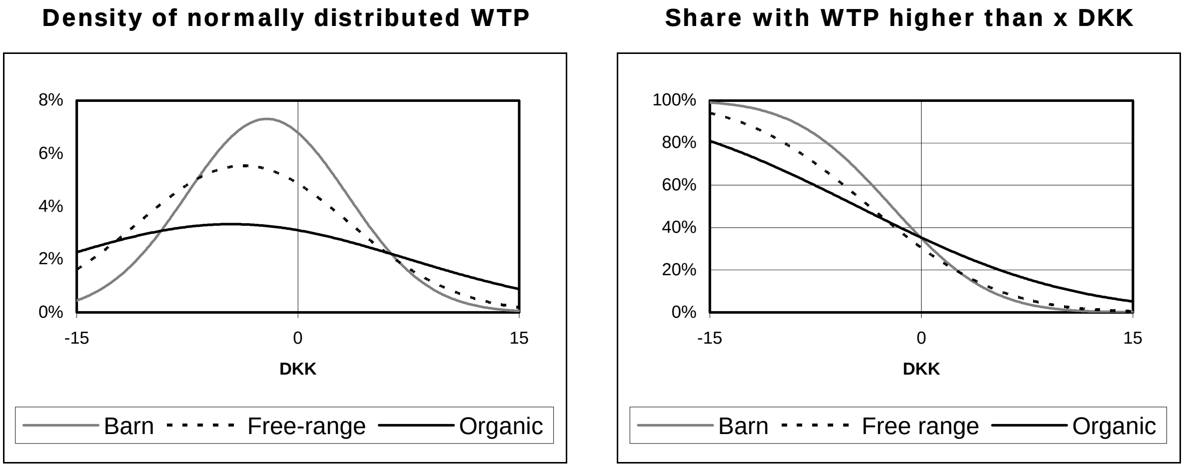
This does not correspond with the expectation that willingness to pay for free-range eggs should lie between the willingness to pay for barn eggs and that for organic eggs. On the other hand, it fits well with the fact that free-range eggs have the lowest market share (see Table 2). One explanation is that households may find it difficult to distinguish free-range eggs from barn and organic eggs. If a household believes that there is no difference between barn and free-range eggs, barn eggs will be chosen because they are cheaper. If a household believes that there is almost no difference between free-range and organic eggs, organic eggs are more likely to be chosen, because organic eggs have a familiar label and may even be perceived as healthier, and are often not more expensive than free-range eggs. Baltzer (2002), who used scanner data from individual COOP stores, also found that the willingness to pay for free-range eggs was lower than for organic and barn eggs.

A conventional logit can be seen as the special case of a mixed logit in which all standard deviations are zero. It is therefore possible to test the need for mixing by a likelihood ratio test with degrees of freedom equal to the number of mixed parameters. In the example in Table 5 the likelihood ratio test becomes $-2\cdot(-12{,}950+8{,}385)=9{,}130$. The degrees of freedom are equal to the number of parameters in the variance-covariance matrix in the mixed model i.e. six in this case. The conventional logit is therefore *strongly* rejected. The estimated negative willingness to pay underlines the fact that the conventional logit does a very poor job of explaining the willingness to pay, because it estimates *one* willingness to pay for all households. The rest of the paper therefore focuses on the mixed model.

In a mixed multinomial logit model both the mean and the variance-covariance matrix of the willingness to pay are estimated, so the ranking of willingness to pay now depends on the share of the population who are willing to pay a given percentage extra, compared to the cost of a battery egg. The expectation is that the share of the population with a given willingness to pay for non-battery eggs is largest for organic eggs and smallest for barn eggs.

The mean willingness to pay in the mixed logit in Table 5 becomes negative for all three types of eggs, but now this simply means that the share of households with positive willingness to pay is less than 50%, and this does not seem unreasonable given the market shares presented in Table 2 (between 10% and 26%). The estimated share of households with positive willingness to pay is 35% for organic as well as barn eggs, and 31% for free-range eggs. The densities of willingness to pay are illustrated in Figure 2. This is a very clear illustration of the importance of standard deviations in a mixed logit. As soon as the price premium becomes positive the share of households who are willing to pay the premium is larger for organic eggs than for barn eggs, even though the mean willingness to pay is lowest for organic eggs.

Figure 2 Illustration of the importance of the standard deviation of willingness to pay (WTP) for different types



The willingness to pay for organic eggs has the lowest mean, but the highest standard deviation. In this case the bigger standard deviation implies that the share of the population with willingness to pay higher than a given positive amount is bigger for organic eggs, even though the mean was lower than for the other types. In this specific case the share with willingness to pay higher than zero is exactly the same as for barn eggs, but that is mere coincidence.

The mixing changes not only the magnitude, but also the ranking of the means. However, as illustrated in Figure 2, the ranking of the means is not necessarily the same as the ranking of the willingness to pay. This difference between conventional and mixed logit is important to keep in mind whenever one tries to interpret results of a mixed logit.

The standard deviation of the willingness to pay for organic eggs is 4.6 ($20.73^{½}$) and the standard deviations for free-range and barn eggs are 2.7 and 2.1. This supports the hypothesis that the organic label suggests other attributes in addition to animal welfare. As expected, the estimated correlation between organic eggs and free-range eggs is larger than the other correlations, which might indicate that households know that free-range and organic eggs are very close substitutes. The correlation between barn and free-range eggs is also higher than the correlation between barn and organic eggs, confirming that barn eggs and free-range eggs are closer substitutes than barn eggs and organic eggs.

The simple mixed model in Table 5 thus confirms the hypothesis that some share of the population has positive willingness to pay for non-battery eggs, that willingness to pay for barn eggs is lower than for organic eggs, and that the variation in willingness to pay for organic eggs is higher than the willingness to pay for barn and free-range eggs.

The mixed model from Table 5 is repeated in Table 6, together with a model where socio-demographics and perceptions of animal welfare and food safety are included. This model splits the sample into sub-samples with different willingness to pay, as explained in equation (8). The new variables are allowed to influence the mean utility of each type of egg, but not the standard deviations. That means that the model estimates differences in mean willingness to pay between households with different perceptions of eggs, and between different socio-demographic groups. The effect of perceptions of animal welfare and food safety is only allowed to influence the willingness to pay for organic eggs, whereas the socio-demographics are allowed to influence the willingness to pay differently for each of the three types of non-battery eggs.

Table 6 Summary of mixing results

Explanatory variable:		Model 1: Only types Estimate	Model 1: St. dev.		Model 2: With perceptions and socio-demographics Estimate	Model 2: St. dev.		LR test
Price		-0.39	(0.122)	***	-0.38	(0.122)	***	
Types of eggs, measured relative to battery eggs								
Means:	Organic	-1.72	(0.200)	***	-4.00	(0.512)	***	
	Free-range	-1.40	(0.134)	***	-2.43	(0.333)	***	
	Barn	-0.80	(0.094)	***	-0.84	(0.241)	***	
Variance:	Organic	20.73	(1.819)	***	17.16	(1.552)	***	
	Free-range	7.56	(0.706)	***	6.77	(0.687)	***	
	Barn	4.31	(0.395)	***	4.17	(0.383)	***	
Correlation:	(Organic, free-range)	0.84			0.81			
	(Organic, barn)	0.66			0.67			
	(Free-range, barn)	0.79			0.71			
Perception of animal welfare in organic eggs, no difference is control group								
Organic	Negative organic animal welfare				-0.17	(0.727)		$\chi_2^2(15.24) = 0.000$
	Positive organic animal welfare				0.99	(0.285)	***	
Perception of food safety in organic chickens, no difference is control group								
Organic	Negative organic food safety				-0.55	(0.697)		$\chi_2^2(12.21) = 0.002$
	Positive organic food safety				0.91	(0.274)	***	
Income, lowest 25% is control group								
Organic	Mid 50%				0.24	(0.329)		$\chi_2^2(5.56) = 0.062$
	Highest 25%				0.71	(0.393)	*	
Free-range	Mid 50%				0.08	(0.230)		$\chi_2^2(4.95) = 0.084$
	Highest 25%				0.49	(0.278)	*	
Barn	Mid 50%				0.10	(0.189)		$\chi_2^2(0.68) = 0.712$
	Highest 25%				0.18	(0.239)		
Age, 60+ is control group								
Organic	Age 18 to 44				-0.88	(0.392)	**	$\chi_2^2(5.27) = 0.072$
	Age 45 to 59				-0.53	(0.305)	*	
Free-range	Age 18 to 44				-0.49	(0.276)	*	$\chi_2^2(4.53) = 0.104$
	Age 45 to 59				-0.47	(0.248)	*	
Barn	Age 18 to 44				-0.70	(0.213)	***	$\chi_2^2(10.18) = 0.006$
	Age 45 to 59				-0.43	(0.205)	**	
Urbanisation, rural municipalities is control group								
Organic	Capital area				2.64	(0.438)	***	$\chi_2^2(39.84) = 0.000$
	Urban municipality				0.72	(0.368)	*	
Free-range	Capital area				1.21	(0.292)	***	$\chi_2^2(17.42) = 0.000$
	Urban municipality				0.64	(0.270)	**	
Barn	Capital area				0.09	(0.240)		$\chi_2^2(0.35) = 0.839$
	Urban municipality				-0.04	(0.209)		
Highest level of education, no further education stated is control group								
Organic	Voc.-oriented high-school				0.51	(0.462)		$\chi_4^2(7.14) = 0.128$
	Short further education				0.77	(0.530)		
	Medium further education				1.12	(0.493)	**	
	Long further education				1.69	(0.852)	**	
Free-range	Voc.-oriented high-school				0.58	(0.287)	**	$\chi_4^2(7.92) = 0.095$
	Short further education				0.82	(0.357)	**	
	Medium further education				0.80	(0.337)	**	
	Long further education				1.09	(0.692)		
Barn	Voc.-oriented high-school				0.37	(0.229)		$\chi_4^2(5.48) = 0.241$
	Short further education				0.26	(0.276)		
	Medium further education				0.59	(0.271)	**	
	Long further education				-0.03	(0.499)		
Log-likelihood		-8,384.65			-8,305.71			
No. of households		844			844			
No. of observations		10,800			10,800			

Estimations using GfK purchase data on eggs from 26 June 1999 to 30 June 2000 combined with answers to AKF/GfK questionnaire from 2002. Purchases made directly from farms excluded. Rationing is allowed. Number of antithetic Halton Draws is 7,500. '***' is significant at the 1% level, '**' at the 5% level and '*' at the 10% level. The LR tests show the results of comparing model 2 with a model excluding variables group by group.

One way of interpreting the results in Table 6 is to look at the predicted share of the population with positive willingness to pay for organic eggs. The utility of money is 0.38 per DKK, and is thus practically unchanged compared to the model based only on prices and types. If a household believes in a positive effect on animal welfare (+0.99), has no trust in organic effect on food safety (+0.00, control group), has a high income (+0.71), has a member who is 60 years old or more (control group), lives in an urban municipality (+0.72) and has a long further education (+1.69), then the distribution of the utility of organic eggs has a mean of 0.11 (= -4.00 + 0.99 + 0 + 0.71 + 0 + 0.72 + 1.69) and a spread ($\tilde{\sigma}_{22}$, see (6)) of 17.16½ = 4.14, which means that the willingness to pay has the mean $-\beta^2/\beta^p$ = -0.11/(-0.38) = 0.29 and standard deviation $-\tilde{\sigma}_{22}/\beta^p$ = -4.14/(-0.38) = 10.89 (see equation (2)). The model therefore predicts that half of the group are willing to pay at least DKK 0.29 more for an organic egg than for a battery egg, and that $51\%\left(=P\left(x>0\middle|x\sim N\left(0.29,10.89\right)\right)\right)$ of the households in the group have a positive willingness to pay for organic eggs compared to battery eggs.

It is important to understand that the parameters for types cannot be compared directly between the two models (and not only because of the change in scale mentioned in the theory section). When socio-demographic factors and perception of organic eggs are included, it means that the estimated means no longer relate to the entire sample, but only to the control group. The mean will therefore change to fit the mean of the control group. The utility of organic eggs is allowed to be influenced not only by socio-demographic factors, but also by perception of organic eggs. The result is that the mean utility drops from -1.72 to -4.00. The estimations show that age is the only socio–demographic factor which influences the utility of barn eggs significantly, and the utility of barn eggs only drops from -0.80 to -0.84.

Introducing socio-demographic factors reduces the estimated variation a little because some of the variation is now captured in the socio-demographics, but the effect is not dramatic. The correlations remain practically the same as in the simple model.

The utility of organic eggs increases significantly when the household trusts that organic production has positive effects on either animal welfare or food safety. The response to the two effects is of approximately the same magnitude. However, the question of food safety is not related directly to eggs, so the effect might be underestimated. This means that purchases of organic eggs are not solely driven by private motives (health), but also by altruistic motives (animal welfare).

Figure 3 illustrates the difference in willingness to pay for households who believe that there is *no difference* between the animal welfare of the hens used in production of organic and battery eggs (the grey line, mean -4.00, see Table 6) and the households who believe in a positive effect (the dark line, mean -4.00 + 0.99 = -3.01, see Table 6). This illustrates the effect of different means, given same standard deviations of willingness to pay. When the standard deviation is the same for the two groups, the group with the highest mean always has the highest willingness to pay, although the difference decreases with the price. Figure 2 and Figure 3 illustrate the importance of knowing the standard deviations when comparing means of a mixed logit.

Figure 3 Households with different perceptions of animal welfare related to organic eggs

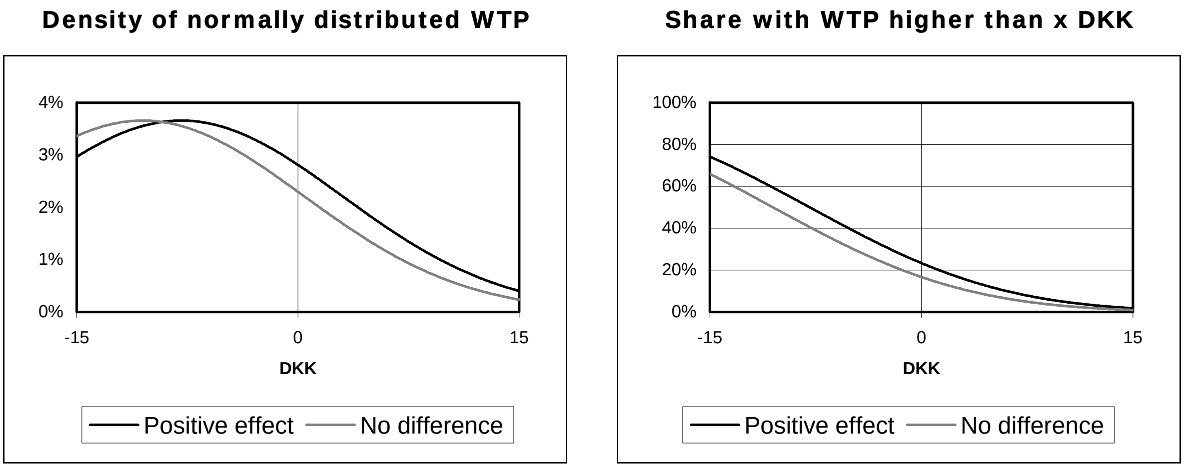


Illustration of the effect of different means, given same standard deviations of willingness to pay (WTP): The willingness to pay for the grey type has the lowest mean, but the same standard deviation as the dark type. This means that the share of the population with willingness to pay higher than a given amount is always bigger for the dark type, although the difference decreases.

The LR tests in Table 6 show the results of comparing the model with perception and socio-demographics with a model excluding variables group by group. The difference between the log-likelihood of model 2 and a model without perception of organic animal welfare is 15.24/2, which means that the LR test rejects that animal welfare can be excluded. At the other end of the scale, the test for the effect of income on barn eggs (probability 0.712) shows that income has no significant effect on barn eggs.

The effect of socio-demographics is very similar for organic and free-range eggs. Income is barely significant, and neither is age. However, urbanisation and to some degree education has a positive effect on the utility of these types of eggs. The picture is somewhat different for barn eggs, where only age seems to make a difference.

7 Conclusion

Expressed concern for animal welfare is not just cheap talk. A significant share of the population is willing to put money on the counter in order to increase animal welfare, even when we control for the private attribute food safety.

Willingness to pay for free-range and organic eggs is higher in urbanised municipalities and for households with relatively high incomes. Higher levels of education also influence the willingness to pay positively. The willingness to pay for barn eggs is mainly influenced by age; the older the household, the greater the willingness to pay.

As expected, the willingness to pay for organic eggs displayed more heterogeneity than was the case for barn or free-range eggs (multiple sources of value, e.g. familiar label and health), and the willingness to pay for organic eggs was generally higher than for barn eggs. Contrary to expectation, the willingness to pay was lowest for free-range eggs. However, this result has been seen in at least one other study using completely different methods. A plausible explanation could be that people either confuse barn eggs with free-range eggs and prefer the cheaper barn eggs, or realise that free-range eggs are close to organic both in attributes and price and therefore prefer organic eggs, which yield both a familiar label and perhaps also an expectation of better health.

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