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Farmers' Valuation of Incentives to Produce GMO-free Milk: A Discrete Choice Experiment.

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Abstract

This paper investigates farmers' willingness to adopt a Genetically Modified Organisms (GMO)-free milk production scheme introduced by the dairy. Incentives like a price premium, advice, quality control and feed procurement are set to encourage the conversion. The analysis is based upon Discrete Choice Experiments with 151 dairy farmers in Germany. Alternative-specific conditional logit estimation reveals the marginal effects of incentives and the amount of compensation. The results indicate that attributes like the price premium, takeover of feed procurement and an external audit affect the likelihood of adoption. Farmer, farm characteristics and attitudes concerning GMO as well as expectations on feed prices were found to be significant determinants of adoption. Moreover the findings demonstrate variation in the values of attributes across regions.

Keywords: GMO-free milk production, choice experiments, incentive instruments

1 Background and Introduction

The on-going concentration on the German milk market and effects of globalization impose pressure on dairy companies to strengthen their competitive strategy. Product differentiation has become a valuable strategy to meet consumer demand by developing value-added products. Genetically Modified Organisms (GMO)-free milk is one such example which has gained significant importance in Germany in particular in Bavaria in recent years (Bayerische Landesanstalt für Landwirtschaft, 2011). Dairies like Friesland Campina Germany GmbH (Heilbronn) or J. Bauer GmbH & Co. KG (Wasserburg am Inn) have included this value added quality concept into their product portfolio. Since consumers in industrialized countries are strongly concerned about the application of genetic engineering in food production (Henseleit, Kubitzki, & Herrmann, 2009; Bansal & Ramaswami, 2007) a market for GMO-free produced food products has grown and has led to the introduction of the voluntary non-GMO-label based on the implementation regulation (EG-Gentechnik-Durchführungsgesetz) that came into effect the 1st of May in 2008. Farmers who accept the requirements for GMO-free milk production must prove that the feedstuffs used are not listed as GMO-feed according to the Regulation (EC) No 1829/2003 and 1830/2003. Such schemes aim to encourage the production of goods by providing the farmer with monetary incentives for provision of these goods (Birol, Koundouri, & Kountoyris, 2008). The amount of payment to the farmer is divers (0.5 to 2.0 ct/kg raw milk) and depends mostly on the marketing success and on the products distributed.
An analysis of costs for non-GMO-soy showed a change of 0 to 0.8 ct/kg milk compared to the conventional feeding costs depending on the share and composition of concentrated feed (Dorfner & Uhl, 2012). Farmers can either use GMO-free soy or switch their feeding regimes to other protein sources such as rape seed meal, grain legumes without suffering losses in yield performance or milk quality (Deumelandt & Bronsema, 2013). Certification and control are important instruments to protect the quality throughout the chain (Bayerische Landesanstalt für Landwirtschaft, 2011) and the farmer has to comply a defined conversion period of three month. Moreover costs of searching alternative feed suppliers or lack of knowledge concerning alternative protein feeds might hinder adoption of GMO-free milk production.

The paper analyses dairy farmer's willingness to adopt GMO-free milk production and their preferences for alternative incentives provided by dairy companies to encourage adoption. More specifically we wish to clarify following questions:

- How great is he willingness to adopt GMO-free production schemes?
- Which attributes of the scheme provide utility and is thus values by the farmer?
- How much influence do the farm structure, the feeding regime and the attitude concerning GMO and expectations on feed prices the adoption behavior?

The analysis is based upon Discrete Choice Experiments with 151 dairy farmers in two German *Bundesländern*, Bavaria (B) and Schleswig Holstein (S.-H.). The data was collected in February and May 2013 using a paper based questionnaire and stratified sampling. Respondents were asked to choose between the status quo and two GMO-free alternatives consisting of several attributes concerning procurement of GMO-free feed, advice given during the conversion process, the audit/control process and a price premium. From each choice set they were asked to choose the preferred alternative or the status quo.
From expert interviews with dairy companies we identified certain problems during the conversion that hinder the adoption of production requirements:

1. Conversion of feeding
2. Additional feeding costs
3. Control
4. Liability

The adoption requires the usage of GMO-free feed, thus the farmer has to decide between the use of GMO-free soy or switching the feeding regime to other protein components. Depending on the current dairy cattle feeding (share of self-production, use of concentrated feed) the supply of feed has to be restructured and new sources of supply have to be identified. The GMO-free equivalent has a higher price around 4 to 8 €/dt compared to conventional soy. Considering the higher protein content additional costs of 0 to 0.8 ct/kg milk are expected. The use of other protein sources such as rape seed meal, grain legumes and the intensity of grassland use might save costs without causing losses in milk yield and quality (Dorfner & Uhl, 2012). Based on this assumption we aim to clarify if the use of soy prior to the conversion and the share of grassland affect the adoption behavior.
To gather transparency throughout the chain and reduce the risk of contamination, the farmer has to control the feeding management; more specifically he has to prove the exclusive use of feed in accordance with the requirements. Additional effort and time of a control (documentation, audit etc.) has to be considered in the decision about the adoption. Based on these problems opportunities were defined that could help the farmer to overcome them and demolish the barriers. Details on the attributes are given in table 2.

2 Literature

The Discrete Choice Experiments (DCE) are mainly applied in health economics (Ryan & Gerard, 2003; Stirling & Dolan, 2004), in environmental economics (Adamowicz, Louviere, & Williams, 1994) and also in market research to analyze the preferences of customers according to product differentiation (Anderson, de Palma, & Thisse, 1992). Only a few studies deal with the decision behavior and evaluation of farmers preferences concerning production schemes in terms of their willingness to accept. Since non-monetary incentives e.g. advice, are not traded with a market price in this context we apply a non-market valuation technique to ascertain their value for the farmer. Espinosa-Goded, Barreiro-Hurle, & Ruto (2010) and Ruto & Garrod, (2009) investigated the ex-ante participation behavior in Agri-environmental schemes and concluded that the acceptance is not only influenced by the attributes of the scheme but also by the regional conditions, by farmer and farm-specific characteristics. Breustedt, Mueller-Scheeßel, & Latacz-Lohmann, (2008) explored the adoption behavior concerning GM oilseed rape and underlined the importance of farm and farm characteristic to the likelihood of acceptance. The present study contributes to the strand of literature by applying DCE to evaluate the farmers' preferences for GMO-free milk production requirements. As the decision making process is influenced by a range of factors (Edwards-Jones, 2006), we also included the impact of the farm structure, socio-economic characteristics and attitudes concerning GMO and feed prices in our analysis. Only a small number of studies have enquired into the influence of farmers' attitudes relating to GMO in agriculture. For example Cook & Fairweather (2003) examined changes in intensions, attitudes and beliefs of farmers regarding the use of GM technology and concluded that the attitudes are key factors for the decision making process. Therefore we hypnotized that the overall attitude concerning GM technology will have an influence on the probability to adopt GMO-free milk production.

3 Methodology

3.1 The survey

The empirical analysis is based upon primary data gathered from 151 dairy farmers in two German *Bundesländern*, Bavaria (B) and Schleswig Holstein (S.-H.) prior to the adoption of GMO-free production scheme. The data was collected in February and May 2013 with the use of a paper based questionnaire following a stratified sampling.

Table 1.

Example of a Choice Set

Attributes	Alternative 1	Alternative 2	Status Quo
Procurement of feed	Farmer	Positive List	Conditions remain unchanged.
Control	Documentation	Documentation	
Advice	No Advice	Premium Advice	
Price Premium (ct/kg)	2.0	0.5	
I choose:	□	□	□

The distribution of the questionnaire was carried out in cooperation with a dairy and a board of milk control. A number of 730 questionnaires were send to dairy farmers in Bavaria and a number of 500 to dairy farmers in Schleswig-Holstein. Of these 1230 a number of 203 returned and out of these 151 (Bavaria 57 and Schleswig-Holstein 94) were suitable for inclusion in the data analysis. The questionnaire confronted respondents with choice sets. Each choice set consisted of two options for GMO-free milk production and a status quo. The respondents were asked to choose the preferred one; either one of the alternatives or the status quo (no adoption). An example for a choice set is shown in table 1. Each of the alternatives is characterized by 4 attributes with different levels. These attributes and levels are explained in detail in table 2.

Table 2.

Attributes and attribute levels in the Choice Set

Attributes	Description	Attribute levels
Procurement of feed	The farmer has to guarantee the feeding of GMO-free feed	A_{sq}: the farmer has to procure the feed by himself B: dairy takes over the complete feed procurement C: dairy provides a list with suppliers of GMO-free feed
Control	Performance of control	A_{sq}: no control B: external audit with certificate for the farmer, no costs for the farmer C: dairy carries out a control (e.g. sampling the feed), no costs for the farmer
Advice	Feed advice and consulting for separation of production lines.	A_{sq}: no advice B: advice by the dairy (only once during the conversion) C: advice plus: frequent advice concerning the feed, feed prices and separation of production
Price Premium (ct/kg)	A premium on the standard milk price for meeting requirements paid by the dairy.	A_{sq}: 0; B:1,0; C:1,5; D:2,0

The choice sets were compiled by means of SPSS which generated 15 sets of all 108 combinations satisfying a balanced orthogonal, fractional factorial design.

3.1 The model

The DCE method is based on the characteristics theory of value (Lancaster, 1966) and the random utility theory assuming that non observable variables affecting the individuals choice (Mc Fadden, 1974; Manski, 1977). Lancaster stated that the utility will be obtained rather from the attributes of the good than from the good itself.

In our model we consider the farmer n as utility maximizing individual, thus he chooses from J alternatives that one with the highest utility U. Therefore he will only convert to GMO-free-milk production, if the expected utility is higher than the utility he obtains from current production.

$$E[U^c] > E[U^n] \ \forall c \neq n$$

The utility function can be seen as a vector of attributes Z_j that are associated with alternative$j$, and a vector of individual characteristics of the farmer S_n (e.g. age, attitude) (Ben-Akiva & Lerman, 1994).

$$U_{jn} \ = \ U\ (Z_j, S_n)$$

Following the random utility approach, we decompose the function in two parts:

$$U_{jn} = V\big(Z_j, S_n\big) + \varepsilon(Z_j, S_n)$$

Where V is non-stochastic and maps the deterministic part that can be calculated by the observable characteristics of the farmer n and the chosen alternative j and the stochastic term ε reflecting the unobserved random variables with zero mean.
The selection of one alternative (y) implies a greater utility than the utility of the other alternative. So the probability that the conversion (subscript c) will be chosen over the non-conversion (subscript n) can be written as

$$P\,(y) = \ Prob\,(V_c + \ \varepsilon_c > V_n + \ \varepsilon_n) \forall\ c \neq n$$

After testing if the IIA assumption holds we could employ an alternative specific conditional logit model also known as Mc Fadden's conditional logit (Mc Fadden, 1974).

Alternative specific conditional logit

The alternative specific conditional logit model is a specific case of the more general conditional logistic regression model (Mc Fadden, 1974) where the farmer n chooses from a set of unordered alternatives $1,2,\dots,J$ the alternative j such that $y_{jn} = 1$ or $y_{jn} = 0$ otherwise.
The model allows two types of independent variables: alternative specific (Z) and case specific variables (S). Alternative-specific variables vary across both cases and alternatives and case-specific variables are individual specific (like age, income and attitude) and vary only across cases. To estimate the probability for the choice of one alternative we set the status quo option as basis alternative and furthermore computed the marginal effects at the mean for the attributes and case variables.
The general form of the model is:

$$P_{jn} = P\left(y_{jn} \middle| s_n, B_n\right) = \frac{e^{z_{jn\theta}}}{\sum_{j=1}^{J_n} e^{z_{in\theta}}}$$

It is assumed that the error components are independently and identically distributed (iid) following a type 1 extreme value distribution. The conditional utility function estimated is

$$U_{jn} = \beta + \beta_1 Z_1 + \cdots + \beta_n Z_n + \delta_1 S_1 + \cdots + \delta_l S_m$$

where β is an alternative specific constant that reflects the difference in utility between alternatives ceteris paribus (Ben-Akiva & Lerman, 1994) thus it captures the effect of utility on any attribute not included in the choice specific attributes. The vectors of coefficients β_1 to β_n depict the marginal effect of attributes of the alternative and δ_1 to δ_l are the influences of socio-economic characteristics of the farmer.
The marginal effects are calculated at the means of the independent variable. The default is all variables and the discrete change in the simulated probability is computed as the indicator variable changes from 0 to 1.

The derivative of the log likelihood is used $\partial l(\gamma \,|\, \eta)/\partial \eta$ where used $\partial l(\gamma \,|\, \eta) = \ \log \Pr(\gamma \,|\, \eta)$ is the log of the probability of the choice indicator vector y given the linear predictor vector η

4 Results

4.1 Descriptive statistics

The descriptive statistics of the whole sample (n=151) is presented in table 3. On average the age of respondents is 44 years, the majority of them are farm managers, thus the decision makers on the farm and over the half of them are foreman or have a college or university degree.

Table 3.

Summary statistics of respondents, n=151

Variable	Mean (min/max)	Standard Deviation
farmers age (years)	44.31 (22/64)	10.28
farm acreage	99.37 (17.66/ 400)	64.99
grassland (ha)	43.8 (5/180)	28.2
percentage of own land	53% (16%/100%)	22.2
arable land (ha)	57.1 (5.5/295)	49.5
number of cows	86 (7/440)	64
milk yield in kg/cow * 305	7155 (2440/10675)	1467.5

Dummy variables	Proportion of affirmative response (%)	Explanation
farm manager	87.42	Respondent is farm manager
successor	49.32	Farmer has a successor
education	53.64	Farmer is foreman or has a college or university degree
organic certification	97.89	farmer has no organic certification
QMM	97.32	A quality management system is implemented
Advice	68.43	Advised farm
Cooperation	41.33	Farmer is member in a cooperation
SES	79.4	Farmer is feeding soy extraction grist

To capture regional differences, we compared the descriptive statistics also for Bavaria and Schleswig-Holstein (see table 4).

We found notable differences in the farm acreage, the amount of grassland, arable land and number of cows. The farm acreage, the area of grassland and arable land is on average in Schleswig-Holstein twice as much as in Bavaria, so is the herd size.

Table 4.

Descriptive statistics of respondents per region

	Bavaria (n= 57)		Schleswig-Holstein	(n= 94)
Variable	Mean (min/max)	Standard Deviation	Mean (min/max)	Standard Deviation
farmers age (years)	46.5 (23/63)	10.4	43.1 (22/64)	10.0
farm acreage	60.37(17.6/188)	64.99	122.09 (41/400)	32.87
grassland (ha)	23.6 (5/68)	13.0	55.6 (11/180)	28.0
percentage of own land	50.5% (21%/100%)	23.2	54.5% (16%/100%)	21.6
arable land (ha)	37.4 (5.5/120)	23.8	68.7 (6/295)	56.7
number of cows	55.1 (7/130)	30.4	104.1 (15/440)	71.6
milk yield in kg/cow * 305	6317 (3355/9546)	1252.5	6107 (2440/10675)	1368.5

Dummy Variables	Proportion of affirmative response	Proportion of affirmative response
farm manager	89.47	86.17
successor	50	48.89
education	49.12	56.38
organic certification	100	97.87
QMM	92.73	100
Advice	65.45	70.21
Cooperation	96.49	7.53
SES	68.42	86.17

A total of 1153 choice sets were includes in the estimation. Each choice set contained two GMO-free schemes, hence n=2306.

Besides the choice experiments questions about the attitude about GMO and expectations on feed prices were included which were surveyed with the use of a five-level likert scale.

4.2 Estimation results

An alternative specific conditional logit was estimated as written in chapter 2.2. We conduct the estimation for the whole sample and calculated the marginal effects on the likelihood of adoption for the whole sample and subsamples of respondents from the two regions. Furthermore we calculated the compensation payment.

From 1062 decisions 50.4 % were answered with the choice for conversion to GMO-free milk production and in 49.6 % of all cases the status quo was preferred. Around 30 % of all farmers have always chosen an alternative and thereby showing a high willing to convert their production, whereas 24 % have never chosen an alternative. The overall probability that an alternative will be accepted is 0.46 (Bavarian farmers 0.50 and for farmers from S.-H. 0.45)

Table 5 shows the estimation results and table 6 reports the marginal effects at the mean of the independent variables and the compensation payment.

Table 5.

Results of the alternative specific conditional logit estimation

	full model		parsimonious model	
likelihood	-322.2		-328.479	
	coefficient (sd)	p-value	coefficient (sd)	p-value
constant	7.304 (788.707)	0.993	-6.334 (1.150)	0.000
price premium	1.455 (0.181)	0.000	1.275 (0.137)	0.000
feed procurement by dairy	-0.848 (0.237)	0.000	-0.901 (0.160)	0.000
external audit	-0.736 (0.229)	0.001	-0.590 (0.155)	0.000
control by dairy	0.057 (0.239)	0.811	-	-
positive list	0.143 (0.208)	0.491	-	-
advice by dairy	0.471 (0.233)	0.044	0.261 (0.148)	0.078
advice plus	0.261 (0.240)	0.276	-	-
age of farmer	0.047 (0.016)	0.005	0.019 (0.008)	0.027
education	0.174 (0.233)	0.456	-	-
income	0.099 (0.146)	0.498	-	-
agricultural advice	0.525 (0.384)	0.172	-	-
commercial farm	-14.503 (788.704)	0.985	-	-
successor	-0.600 (0.283)	0.034	0.327 (0.168)	0.052
grassland share	-0.434 (0.880)	0.622	-	-
own land share	-0.007 (0.007)	0.339	-	-
cows	-0.003 (0.003)	0.345	-	-
region	1.557 (0.806)	0.053	-	-
income from milk production (%)	-0.620 (0.316)	0.000	0.007 (0.004)	0.061
milk performance	0.029 (0.008)	0.000	-	-
member in cooperation	1.436 (0.625)	0.022	-	-
feeding SES	-0.891 (0.388)	0.022	-1.085 (0.219)	0.000
negative impact of GMO soy in producing countries	-0.402 (0.162)	0.013	-0.316 (0.082)	0.000
price development (compared to current year)	0.418 (0.186)	0.025	0.219 (0.093)	0.018
price tendency (next 10 years)	0.115 (0.155)	0.457	-	-
consumers WTP for GMO-free milk	-0.162 (0.136)	0.232	-	-
GMO-free milk as short-term trend	0.010 (0.155)	0.949	-	-
expectation of feed price (soy and rape seed)	0.0002 (0.0003)	0.031	-	-

From the attribute variables the price premium, the feed procurement by the dairy and the external audit are highly significant and advice by the dairy at the ten percent level. The attributes control carried out by the dairy, the positive list and advice plus were omitted from the estimation. Following a likelihood-ratio test (LR) 14 other variables were excluded from the model due to insignificance.

The feed procurement and the external audit have positive influences on the probability of conversion. An explanation might be the costly and time consuming re-organization of feed procurement. The external audit is often time consuming and related to high effort for the farmer to prepare. The control carried out by the dairy and the advices during the conversion have positive influences on the conversion. This indicates that a lack of know how hinders the adoption of requirements for the GMO-free production.

Due to the increasing demand for GMO-free food products it might be reasonable that a number of farmers would adopt this production concept expecting a higher return. From literature and expert opinion it can be seen, that especially the conversion period is a critical phase for the farmers in which the investment costs are higher than the additional price premium. In this case incentive instruments like procurement of feed, the assumption of control (or costs of control) and advice might play an important role for the adoption behaviour. It will be expected that the feeding management and the attitude concerning GMO will have a significant influence.

The probability that an alternative will be chosen is 48.15%. If the dairy pays 1 ct per kg more to the farmer, the probability that the conversion will happen increases by 29 %.

Table 6.

Marginal effects on the probability of adoption for whole sample and subsamples (from parsimonious estimation)

marginal effects	whole sample		Bavaria		Schleswig-Holstein	
	dp/dx percentage points	compensation (-1βattr/βcost)	dp/dx percentage points	compensation (-1βattr/βprice)	dp/dx percentage points	compensation (-1βattr/βcost)
price premium (change +1 ct/kg)	**31.57*** **		**49.10*** **		**27.6*** **	
feed procurement by dairy	**21.44*** **	**0.68 ct/kg**	**26.00*** **	**0.52 ct/kg**	**19.94*** **	**0.72 ct/kg**
external audit	**14.19*** **	**0.45 ct/kg**	**24.97*** **	**0.51 ct/kg**	**10.14** **	**0.36 ct/kg**
advice provided by dairy	-6.39*	0.20 ct/kg	-6.95 (not significant)	0.14 ct/kg	-6.31(not significant)	0.23 ct/kg
age of farmer	**0.47** **	**0.015 ct/kg**	1.02*	0.020 ct/kg	0.43*	0.016 ct/kg
successor (dummy)	8.09*	0.26 ct/kg	**43.78*** **	**0.89 ct/kg**	0.80 (not significant)	0.03 ct/kg
income from milk production (change +10%)	**0.171** **	**0.005 ct/kg**	**0.39** **	**0.008 ct/kg**	**0.25** **	**0.008 ct/kg**
feeding soy extraction grist (dummy)	**-26.32*** **	**0.67 ct/kg**	**-32.02*** **	**0.65 ct/kg**	**-23.06** **	**0.83 ct/kg**
negative impact from GMO on biodiversity[1]	**-7.84*** **	**0.28 ct/kg**	**-10.72*** **	**0.37 ct/kg**	**-6.93** **	**0.25 ct/kg**
expectation of feed price development[2]	**5.56** **	**0.20 ct/kg**	**-11.09** **	**0.022 ct/kg**	**9.87*** **	**0.35 ct/kg**

significance level: *** p < 0.001; ** p < 0.05; * p < 0.1

The results indicate that there is a potential for conversion to GMO-free milk production among dairy farmers: in 50.3 % of choices were in favor of GMO-free production. As expected, the price premium has a strong positive effect on the adoption probability as has feed sampling by the dairy company with no costs for the farmer. Providing advice during the conversion period can further motivate farmers to adopt GM-free milk

[1] from fully agree to fully refuse

[2] from very stable to prices fluctuate strongly.

production. Anti- GMO and pro animal welfare attitudes also have a positive influence on adoption behaviour as have expectations of instable feed prices.

- The price premium shows the highest positive influence on adoption behavior (in Bavaria higher impact).
- Feed procurement and external audit show a positive impact on adoption.
- Differences in valuation of attributes by region (e.g. increasing income from milk production).
- Feeding SEG reduces the likelihood of adoption.
- Advised farms show a higher acceptance for conversion, also farms with a successor.
- Attitude variables play an important role for the adoption behavior.
- Further aspects: mixed logit model for preference heterogeneity, role of trust between dairy and farmer, availability of GMO-free feed, consumer behavior/market potential.

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