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Perception of Carbon Footprint and Local Origin Labelling on Drinking Milk

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ABSTRACT

This study investigates preferences of Austrian consumers for carbon footprint labels. To simulate realistic market conditions, carbon footprint labels are tested in addition to the product attributes of local and organic production as well as labels referring to quality guidelines on a hypothetical market of drinking milk. The study evaluates preferences and willingness-to-pay including carbon reduction claims and local production claims. Via a discrete choice experiment, utility functions are approximated and willingness-to-pay estimations are used to quantify premiums associated with the investigated attributes. Results suggest consumers are willing to pay premiums for carbon labeling. However, these premiums are lower compared to local origin and quality claims. Local production claims are viewed as the most important out of the six investigated product attributes. Nevertheless, participants are willing to pay premiums for information on carbon emissions, in particular, if the carbon footprint label indicates a significant reduction of associated greenhouse gas emissions.

Keywords: discrete choice experiment, choice based conjoint analysis, willingness-to-pay, local food, carbon footprint, labeling, milk

1 Introduction

Local production of food is often perceived as a countermovement to the globalized food trade (e.g., Ermann et al., 2018). In addition, with more environmentally sound food products (such as organic food), local food established itself as an important product characteristic in Austria’s food retail market. Reasons for this consumption trend can be found in perceived quality and health benefits, in the environmental impacts of food production (where local food is perceived to have smaller impacts), but also in a diminishing trust in the global food network and its food safety (Feldmann and Hamm, 2015). Local production can have different meanings for consumers. For instance, depending on the person and the product, the definition of “local” depends on the distance to the place of production, political (municipality, district and state) or cultural boundaries (Feldmann and Hamm, 2015). In addition, an environmental dimension is often added to local production claims. Likewise with organic production – which was originally invented as an extensive countermovement to industrial production, today is widely linked with environmental benefits – local food production is often communicated in combination with reduced carbon footprints by means of shorter transport distances (Caputo et al., 2013).
While extensive research has been published on the positive effect of local production on consumers’ utility and willingness to pay premiums, less is known about specific consumer segments that drive those developments and their share of Austria’s dairy market. Little knowledge exists on the performance of specific labels and their interaction with established brands, labels and value-added claims on Austria’s retail market. There is also a lack of the effects of carbon footprints, mainly due to its complexity. Consequently, the performance of explicit carbon reduction statements on the packaging and its interaction with established value-added labels as well as local production claims becomes a valid research interest. Given these findings, this study aims to answer the following research questions (RQ):
RQ1: How do consumers value selected attributes of drinking milk, in particular local and carbon labeling?

RQ2: How much are Austrian consumers willing to pay for information on local origin and carbon emissions of drinking milk?

2 Materials and methods

Discrete choice modeling: Discrete choice models have been used extensively to get a glimpse of consumers' decision-making process in agroeconomics and food sciences. They are based on the Random utility theory (RUT), as described by McFadden (1974) to analyze consumer decision making. Confirming RUT, individuals use a utility function when facing a choice situation, that gives utility to every selectable alternative. As a result, an individual facing a choice situation will pick the alternative subjectively associated with the highest utility. Hence, a utility maximizing behavior is inferred. Unlike the actual choices made by individuals, the utility itself cannot be observed. Therefore, the utility function is described by a deterministic component, that being the choices made, and a stochastic component which constitutes the error term (Train, 2009).

DCEs are characterized by letting participants choose an alternative out of a set of alternatives that is described by combinations of attributes investigated in the experiment. The number of alternatives must be finite. Further important assumptions are the mutual exclusiveness and the exhaustiveness of alternatives (Train, 2009). As a result, the observed variable, in other words the recorded choices, is of a nominal nature, which sets DCEs apart from classical conjoint analysis (CA), that is based on ranking and rating scales. Theory on discrete choice arises from the work of Thurstone (1994) on paired comparisons. While Thurstone's comparative judgements (1994) ultimately contributed to the development of a variety of models, recent work in econometrics takes predominantly place within the framework of RUT, which is attributed to the work of McFadden (1974). The core of that work lies in a generalization of logit models for more than two alternatives. Subsequently giving the most well-known model, or for that matter transformation, of choice modelling, namely the multinomial logit (MNL). Another possibility (used in this study) is the utilization of Bayesian methods using a Gibbs sampler with a Metropolis-Hastings (MH) step to update a prior distribution (Allenby and Rossi, 1998; Lenk et al., 1996). Both approaches are reported to be consistent, require panel data and, assuming sufficiently large sample sizes, produce parameters that can be interpreted in the same way (Huber and Train, 2001).

Willingness-to-pay: Willingness-to-pay (WTP) gives the maximum price an individual is ready to pay for a product or service (Wertenbroch and Skiera, 2002). At that price, the value of the good or service equals the value of the money, and an individual is indifferent between buying and not buying (Schmidt and Bijmolt, 2020). WTPs are therefore an important tool to (i) be used as input to adapt existing pricing strategies (Schmidt and Bijmolt, 2020), (ii) find an introductory price for new products (Ingenbleek et al., 2013) as well as (iii) determine the welfare effect of public policies (e.g., Florax, 2005; Lusk et al., 2005; Rotteveel et al., 2020). Confirming Sillano and de Dios Ortúzar (2005) our WTP approach constitutes "[…] *a WTP value derived from the coefficients of the 'average individual'* […]" based on partworth utilities approximated by means of a DCE.

Attributes and Levels: The product attributes, characterizing the alternatives of the DCE, are depicted in Table 1. One group of attributes reflects quality specifications that can be found on a real milk package in an Austrian supermarket. Selected labels reflect well-known and researched concepts with at least some a priori knowledge (Hu et al., 2012; Pippan, 2019) on their effect on consumers' utility function which will serve as a control to compare local food and carbon labels against. These labels are (i) the European Union's label for organic production, (ii) Agrarmarkt Austria Marketing GmbH's quality seal (*AMA-Gütesiegel*) and (iii) the hallmark representing production according to ARGE Heumilch Österreich guidelines.

Table 1. Choice Experiment Attributes, Attribute Levels and Coding.

Attribute	Code	Attribute Levels	Description
Local Origin	1	REG0 (base)	No declaration of local origin
		REG1	Label plainly stating: "of local origin".
		REG2	From the federal State of Salzburg
Quality Seal	2	A0 (base)	No AMA quality seal
		AMA	Quality seal by AMA Marketing GmbH
Organic Production	3	O0 (base)	No organic production
		ORG	Organic production
Hay milk	4	H0 (base)	No additional quality parameter
		HAY	Produced under the Hay milk guidelines
Carbon Footprint	5	CB00 (base)	Base carbon footprint of 1,990 g*
		CB05	CO_2-emissions reduced by 5 % 1,891 g
		CB10	CO_2-emissions reduced by 10 % 1,791 g
Price	6	P099 (base)	€0.99 basic price level

	P119	€1.19 price level
	P139	€1.39 price level
	P159	€1.59 price level

* Values used from Kiefer et al. (2015).

In addition to labels already established on the Austrian dairy market, two labels, participants were not familiar with, were created for the purpose of this study and added to the hypothetical market (local origin attribute REG (1), labels in Figure 1). Participants were either shown no local origin label, a label suggesting product origin within the participants' federal state or an indicator describing origin within the Austrian region of Ennstal, respectively.
The Quality Seal of Agrarmarkt Austria Marketing GmbH "*AMA-Gütesiegel*" (AMA) signals production according to guidelines published by Agrarmarkt Austria Marketing GmbH (2022) with special focus on a declaration of origin. Organic production (3) is signaled to participants by the EU organic farming logo. The hay milk (4; HAY) label can be licensed for milk products from ruminants fed and kept in line with guidelines of ARGE Heumilch Österreich (2022, 2024). For the CO_2 label (5) results of a LCA (Kiefer et al., 2015) are presented to participants in a graphic form. Absolute numbers on carbon footprints in CO_2-equivalents are provided in addition to relative statements (0%, 5%, 10% reduction; Figure 1). A price variable (6) is constructed containing four different price levels representing retail prices for milk within Austria. (€0.99 to €1.59).

Figure 1. Example of choices between product 1,2,3 and no-choice option (choice set #3; original in German language).

Sample: The sample amounts to n = 255. However, based on several quality criteria only 182 respondents could be used for approximating partworth utilities. For instance, a certain number of respondents only selected the no-choice option. These data were excluded from the final data set as it is not useful to approximate utilities based on continuous no-choices. The sample's gender distribution is approximately balanced with about half (54.4 %) of respondents identifying as female. Participants in general were, however, considerably younger than Austria's population with more than half of the sample (51.4 %) being less than 26 years of age and only 14.0 % older than 44. Respondents were higher educated and had less income. The convenience sample therefore does not correspond with the overall Austrian population which has to be considered when interpreting the results of the DCE.

3 Results

Individual's answers in the choice experiment were used to model utility changes linked to attributes described above. Altogether a dataset of 2,002 choices of 12 choice sets (e.g., Figure 1) by 182 individuals were available for the analysis to approximate distributions and coefficients on choice behavior using conditional MNL and Hierarchical Bayesian models.

Partworth utilities: Coefficients β_i presented in Table 5 show negative values for the price coefficients (β_{P119}, β_{P139} and β_{P159}) with effect size increasing for higher price levels. An exception to this is the coefficient for the P139 price level, which despite still being negative ($\beta_{P139} = -0.32$) when compared against the base level, influences the utility function less than the P119 price level ($\beta_{P119} = -0.42$). The CB10 carbon reduction level is connected to higher part-worth utilities ($\beta_{CB10} = 0.91$) then the CB05 level ($\beta_{CB05} = 0.26$). Concerning different regions of origin, the coefficient describing the production within a participant's federal state (β_{REG1}) outperforms the coefficient describing production within the region of Ennstal (β_{REG2}). Coefficients describing effects of the Austrian quality label ("AMA Gütesiegel"), origin (ORG; state of residence of respondents or a specific region in Austria) and the attribute hay milk (HAY) are expectedly linked to positive part-worth utilities. Coefficients are all significant at $p \leq 0.05$ (Table 5). Confirming likelihood ratio tests both, the conditional MNL model as well as the Hierarchical Bayesian model, are found to significantly ($p < 0.05$) differ from a null model (every alternative is equally likely to be chosen) at 10 degrees of freedom. Log-likelihoods for the null model and the conditional model are reported in Table 5. The coefficients of the MNL differ from the HB model primarily in effect size and the sign of the alternative specific constant (ASC). In addition to summaries of posteriors from a HB model, Table 5 reports maximum likelihood estimators for a multinomial logit (MNL) model to serve as a base line for a model specified without incorporating random heterogeneity. Base levels of attributes and the ASC linked to buying milk are excluded from the results as they were kept to zero in the analysis. This shall, however, remind the reader that the reported point estimates are to be interpreted as the change in utility gained or lost in comparison to the base level of an effect.

Table 2: Regression coefficients for the conditional MNL model and descriptive statistics on individual-level posteriors from a HB model.

Attribute	Code	MNL		Hierarchical Bayes		
		β	SE	$\overline{\beta_n}$	σ	CI[1]
ASC-NC	ASC-NC	-0.37*	1.24	1.34	1.83	[2.44, 2.45]
Price €1.19	P119	-0.42*	0.19	-0.92	0.90	[-2.58, 0.92]
Price €1.39	P139	-0.32**	0.12	-0.31	1.86	[-2.04, 1.50]
Price €1.59	P159	-1.13***	0.16	-2.12	2.92	[-3.91, -0.35]
AMA	AMA	1.48***	0.11	3.16	1.01	[1.41, 4.96]
Organic	ORG	0.66***	0.10	1.61	1.23	[-0.15, 3.38]
Hay milk	HAY	0.29***	0.09	0.82	1.02	[-1.03, 2.53]
Carbon (1898 g)	CB05	0.26*	0.11	0.25	0.82	[-1.53, 2.00]
Carbon (1990 g)	CB10	0.91***	0.11	1.67	0.72	[-0.03, 3.46]
Region Federal State	REG1	1.63***	0.13	3.28	1.50	[1.45, 5.01]
Region Ennstal	REG2	1.35***	0.14	2.71	1.19	[0.89, 4.49]
LLH		-1753.27			-476.52	
RLH		43.62			78.89	

Significance for the Wald χ^2 Test: *** for $p \leq 0.001$, ** for $p \leq 0.01$ and * for $p \leq 0.05$; Initial Log-Likelihood under a Null-Model of -2,439.88; [1] Based on 10.000 draws from $N(\beta_n, \sigma)$.

Within the utility function, the coefficient specific to the no-choice-alternative describes the utility gain from choosing an alternative without obtaining a product over choosing an option that yields a product. The difference in utility associated with this alternative-specific characteristics is captured by $\beta_{ASC\text{-}NC}$. The ASC for the no-choice option, is on average positive ($\beta_{ASC\text{-}NC} = 1.34$). Part-worth utilities for the €1.19 price attribute (β_{P119}) are on average negative varying from min -3.56 to max 0.61 over individuals (95% CI = -2.58 to 0.92). By contrast, 90 out of the sample's 182 individuals gain utility from the presence of the €1.39 price attribute (min -5.84; max 3.44; CI = -2.04 to 1.50) when compared against the €0.99 base level (β_{P099}.= 0). For these participants, the lowest price might be connected to a lower product quality. Mean part-worth utilities on the individual-level posteriors for the effect of the of AMA are positive for all individuals (min 1.04; max 5.45; CI = 1.41 to 4.96). Also, ORG and CB10 are almost in all cases connected to positive partworth utilities, at least if we look at CI. The general interpretation of these findings is that usually, individuals have divergent preferences in view of most attributes of milk with few exceptions mentioned above. Majorities of individuals (90 % and 77 %, respectively) draw utility gains from the presence of the labels linked to the attributes organic (ORG) and hay milk (HAY). Both attribute levels, the federal state (REG1) as well as the specific Austrian region (Ennstal) label (REG2), can predominantly be linked to positive part-worth utilities. In average, REG1 provides the highest partworth utility of all attributes (3.28), followed by the hallmark AMA (3.16) and REG2 (2.71). All of these attributes are connected to origin. Obviously, domestic manufacturing of drinking milk is of highest preference for respondents.

Results for the label for a 5% carbon reduction (CB05) show individuals' part-worths vary from min -1.34 to max 2.35 (CI = -1.53 to 2.00). Even though the MNL model suggest, that CB05 is significant on an 5% level, the part-worths for the CB05 level are for many respondents close to zero, with 43 % of individuals located in an area of -0.50 to 0.50. Thus, utility gains from a reduction in CO_2-equivalents from 1,990 g CO_2 to 1,887 g CO_2 are small if at all different from zero. By contrast, lower-level posterior means are positive for 181 out of the 182 individuals for the CB10 reduction statement. Thus, a reduction from 1,990 g CO_2 to 1,791 g CO_2 results in utility gains ranging from min -0.09 to to 3.50 (CI = -0.03 to 3.46). The difference in utility changes from the CB00 vs. CB05 and CB00 vs. CB10 comparisons was expected, as one can assume that a rational decider would favor larger reductions over smaller ones. However, to attract consumers to buy more ecologically friendly milk products might require high levels of carbon footprint reduction.

Willingness-To-Pay (WTP): WTP is defined as the ratio of the mean value of an attribute's distribution (β_a) to the negative mean value of the price's distribution (β_p). The WTP approximation of that ratio is described in Equation (1).

$$\text{WTP} = \frac{\beta_a}{-\beta_p} \tag{1}$$

As the price attribute is dummy-coded in our model, three different MRSs corresponding to three price levels compared against the base level exist. One approach (e.g., Meixner et al., 2024; Wilcox, 2006) to solve that problem is interpolation. Thus, a regression line is fitted through the individual-level part-worths for the price levels plotted against the monetary value corresponding to the price levels. The resulting slope of the regression line is used as the exchange rate of utility per unit of price or the denominator in Equation (1).

The posterior means summarized in Table 2 give an overview of the distribution in the population. These are expressed in scaleless utilities. Coefficients in preference space are well suited to describe effects of the sample population. However, their absolute values have little meaning for the real world. Hence, high utility changes associated with a binary change in product attributes have different meanings for an individual with equally high changes in the corresponding price attribute and an individual with utility changes in the price attribute an order of magnitude smaller. Normalization, by the marginal rate of substitution (MRS) of price and utility is, thus, recommended to allow for a better comparison among individuals.

The exchange rates of utility against price were calculated using a linear regression on the individual-level utilities for the different price levels revealing a slope for the average individual of -2.87. One unit of utility is traded against €2.87 by the average individual of the sample. The premiums are depicted in Table 3. The WTP measures suggest respondents are willing to pay the highest premium for milk produced in the respondents' federal state REG1 followed by REG2. Also, the attributes AMA, CB10, ORG, and HAY are approximated to produce positive WTP. By contrast, CB05 might be connected to a low WTP with only 0.09 (Table 6).

Table 3: WTP of attributes.

Attribute	Level	WTP [€]
AMA	AMA	1.10
Organic	ORG	0.56
Hay milk	HAY	0.29
Carbon (1898 g)	CB05	0.09
Carbon (1790 g)	CB10	0.58
Region Austrian State	REG1	1.14
Austrian Region Ennstal	REG2	0.94

4 Discussion

Altogether, our findings reflect those described by previous studies on drinking milk and tomatoes (Hartig, 2020; Pippan, 2019). Even though our convenience sample limits representativeness of results, our findings validate observations made by Janßen and Langen (2017) for the German dairy market. Furthermore, the ranks of product attributes, are consistent with importance rankings published by Agrarmarkt Austria Marketing GmbH (2021). The attributes included in the choice experiment focus on local origin and information on carbon emissions, in accordance with the research questions. Other important product characteristics such as animal welfare or production free of the use of GMOs were not included. Literature (e.g., Liljenstolpe, 2008; Wägeli et al., 2016), however, suggests that these concepts do have an influence on consumers' utility. These attributes and their interaction with local production claims and carbon labels may serve as inspiration for future research.

Results regarding the labeling of milk as local or carbon emission reducing are in line with comparable research on the topic (e.g., Caputo et al., 2013). Local production claims, consistent with works of Onozaka and McFadden (2011), Darby et al. (2008) or Meas et al. (2015), thus, can be connected to a positive effect on participants' utility function if present. The local origin factor is designed to reflect a distance decay (REG1 vs. REG2). In contrast to results from Meas et al. (2015) and Hu et al. (2012) who could not find a significant effect of a production within a respondents' federal state claim over a production in one of the federal states claim, utility changes from REG0 vs. REG1 and REG0 vs. REG2 comparisons are differentiable in our study. This differences in average utilities for the local attribute levels may reflect contrasting interpretations of the presented levels comparable Aprile et al. (2012) on PDO claims outperforming comparatively simpler PDI claims. However, over the full sample population and in line with above mentioned works of Meas et al. (2015) and Hu et al. (2012), no preference for one of the local levels considering confidence intervals could be found. Furthermore, local origin indicators are not set mutually exclusive to the country-of-origin indicator, represented by the AMA hallmark, in the present set of attributes. While it is common practice (e.g. Darby et al., 2008; Meyerding et al., 2019; Onozaka and McFadden, 2011) to consider different degrees of local including a national or local level opposing an imported product or no designation base level, the design in Table 1 allows for a substate declaration of origin to be understood as additional information rather than a substitute. This is in line with the research goals of the study, investigating the effects of introducing additional labels rather than providing proof that premiums for local production exist. Results for carbon labels do play a subordinate role in view of the average individual's overall utility change. This is consistent with findings from Onozaka and McFadden (2011) and Caputo et al. (2013) on tomatoes and apples, where the carbon reduction attribute is consistently outperformed by organic production and local production claims. Interestingly, premiums for carbon reduction labels (Table 3) are higher than for the HAY attribute and comparable to those obtained for organic production claims. As these concepts are partly overlapping (Onozaka and McFadden, 2011) further research including interaction terms is needed. The present results suggest that consumers are willing to pay for information on the carbon footprint, in particular, if the reduction of greenhouse gases is a significant one (CB10). By contrast, previous research on tomatoes and apples by Onozaka and McFadden (2011) has suggested that consumers are willing to pay little to no premiums for a 10 % carbon reduction. While WTP values may be interpreted with care and should not be taken for real world prices, results suggest that consumers are willing to pay premiums of €0.27 per 100 g CO_2 reduction in the present experiment. These results are backed by a conditional posterior on the mean utility change of the CB10 attribute that can be distinct from zero comparable to Caputo et al. (2013), finding that participants are willing to pay for information on carbon footprints. Results are further in line with Onozaka and McFadden (2011), who noted that premiums on carbon footprints are influenced by the magnitude of the reduction statement.

There is an ongoing discussion in food sciences if local production claims substitute or add to organic claims (Adams and Salois, 2010; Denver and Jensen, 2014; Hempel and Hamm, 2016). This work is in line with the field as it provides proof that local and organic production are perceived as two separate concepts with overlaps in some areas.

One major shortcoming of DCEs is their hypothetical nature as participants may behave inconsistently when their choices have no real-world implications. The resulting hypothetical bias may lead to exaggerated WTP values (Lizin et al., 2022). Participants were therefore informed on the hypothetical nature of the experiment and respondents' tendency of value inflation ex-ante. Nevertheless, they do show signs of a social desirability bias. Thus, care is appropriate when interpreting absolute values of WTP results. Nevertheless, even when considering hypothetical und social desirability biases, results confirm that participants are willing to pay premiums for the product attributes used in our DCE, in particular, for local production and carbon reduction claims.

5 Conclusion

This study contributes to the vast research on consumer behavior and responses towards local production and carbon reduction claims. The addition of a local production label generally resulted in positive part-worth utilities for the attribute confirming that consumers are willing to pay for additional information on local production on drinking milk. Participants have no preference for a local claim indicating production within the participants own federal state or production within a specific region of Austria. Participants, moreover, showed that they are willing to pay premiums for information on carbon footprints. Premiums on carbon reduction statements are dependent on the magnitude of reduction; only significant ones (here 10%) seem to be connected with higher WTP.

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