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Anne Odile Peschel, Carola Grebitus, Bodo Steiner, Michele M. Veeman

Institutions: Aarhus University, Arizona State University, University of Southern Denmark, University of Alberta

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Title page

How does consumer knowledge affect environmentally sustainable choices? Evidence from a cross-country latent class analysis of food labels

Anne O. Peschel[1], Carola Grebitus[2*], Bodo Steiner[3] and Michele Veeman[4]

[1] MAPP Centre - Research on Value Creation in the Food Sector for Consumers, Industry and Society, Department of Economics and Business Economics, Aarhus University, Denmark

[2] Morrison School of Agribusiness, Arizona State University, USA

[3] Danfoss Center of Global Business, Department of Border Region Studies, University of Southern Denmark, Denmark

[4] Department of Resource Economics and Environmental Sociology, University of Alberta, Canada

* Corresponding author:

Carola Grebitus, Morrison School of Agribusiness, W.P. Carey School of Business, Arizona State University, 7231 E. Sonoran Arroyo Mall, Mesa, AZ 85212, Phone (480) 727-4098, carola.grebitus@asu.edu

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Abstract

This paper examines consumers' knowledge and lifestyle profiles and preferences regarding two environmentally labelled food staples, potatoes and ground beef. Data from online choice experiments conducted in Canada and Germany are analyzed through latent class choice modelling to identify the influence of consumer knowledge (subjective and objective knowledge as well as usage experience) on environmentally sustainable choices. We find that irrespective of product or country under investigation, high subjective and objective knowledge levels drive environmentally sustainable food choices. Subjective knowledge was found to be more important in this context. Usage experience had relatively little impact on environmentally sustainable choices. Our results suggest that about 20 % of consumers in both countries are ready to adopt footprint labels in their food choices. Another 10 – 20% could be targeted by enhancing subjective knowledge, for example through targeted marketing campaigns.

Key words: carbon footprint; food; latent class analysis; objective knowledge; subjective knowledge; water footprint

Introduction

Many dimensions of sustainability are relevant for socio-economic policy making related to ecological issues, including the economic, societal and environmental pillars (Krajnc & Glavič, 2005; Seghezzo, 2009). In this regard, consumers are mainly concerned with favorable economic outcomes and the environment, i.e., environmental sustainability (Choi & Ng, 2011). Given personal and environmental consequences of choosing sustainable products (e.g., IPCC, 2007), it is important for society and policy makers to better understand reasons underlying environmentally responsible consumer behavior. For example, recent research shows that many consumers are displaying an increasing awareness of and preferences for environmental sustainability, as well as an increased willingness to pay for socially and environmentally responsible products (Tully & Winer, 2014). Nevertheless, research is lacking as to what drives such preferences and willingness to pay. In other words, better understanding of the drivers of consumer choices associated with environmentally labelled products is needed. This paper aims to analyze the role of consumer knowledge (objective, subjective, and usage experience) regarding environmentally sustainable behavior, providing evidence from latent class analysis of preferences towards selected sustainability labelled food products, based on investigations in Canada and Germany.

Sustainability food labels have mainly been developed around the ecological footprint concept of Rees (1992) that includes both the amount of CO_2 created (carbon emission) and water used during production, processing, storage, packaging and distribution. The footprint concept provides an intuitive framework for understanding the ecological bottom-line of sustainability (Rees & Wackernagel, 1996; Wackernagel & Rees, 1997). A rapidly expanding literature has provided water and carbon footprint assessments with corresponding consumer and producer perspectives (e.g., Chapagain, Hoekstra, Aldaya, & Mekonnen, 2011; Finkbeiner, 2009; Grunert, Hieke, & Wills, 2014).

To date, a number of countries and retailers have established pilot projects in support of the reduction of carbon emissions by providing information through product labelling. The first footprint labels were introduced in 2007 in the UK (Economist, 2011), followed by the introduction of the first carbon footprint label in food retailing by Tesco in 2009. Tesco cooperated with the Carbon Trust to implement the carbon footprint but discontinued labelling products in early 2012 when it became clear that shoppers were unwilling to pay premiums for labelled products and competitors did not follow suit in labelling their products (Financial Times, 2012; Upham, Dendler, & Bleda, 2011). Consequently, even though a majority of individuals were found to favor carbon labelling and agreed that this should be mandatory (72% of EU citizens) (Minx, 2007; Upham, et al., 2011), there are only a few footprint labels that have continued in the marketplace (e.g., Powers, 2011; Stancich, 2011).

Our research extends previous work (e.g., Grunert, et al., 2014; Grunert, Scholderer, & Rogeaux, 2011; Mesías Díaz, Martínez-Carrasco Pleite, Miguel Martínez Paz, & Gaspar García, 2012) by accounting jointly for consumers' subjective and objective sustainability knowledge as well as for usage experience (e.g., with regard to previous "green" purchases) in the context of food choices. Furthermore, our choice of products allows us to assess possible differences in consumer responses for two staple food products by analyzing consumers' choices for ground beef and potatoes labeled for environmental sustainability, using the example of carbon and water footprints. We contribute to the literature of sustainable food choices by identifying consumer segments in North America (Canada) and Europe (Germany) regarding a variety of characteristics, such as membership in environmentally active groups. Finally, we extend single-region focused literature by accounting for differences in choice behavior across Europe and North America, thereby contributing to the literature that has focused on cross-cultural comparisons (Loose & Remaud, 2013). Specifically, the Canadian study was replicated with German consumers to

assess possible regional differences. Our results show that it is important to use a segmenting approach to analyze choices. We include psychometric and demographic variables in latent class choice models, to identify meaningful differentiations between segments (Boxall & Adamowicz, 2002), and to provide novel insights on the underlying reasons for low self-reported experience, complementing previous conjoint-based analyses (Grunert, et al., 2014).

From a marketing and policy perspective, we derive implications for information provision and suggest target groups that can be addressed through distinct marketing strategies.

The remainder of the paper is structured as follows. The next section reviews relevant literature, followed by an outline of the methodological approach. Subsequently we present the estimation results and finish with a discussion and conclusions.

Literature

Environmental sustainability labels

The focus of our paper lies on environmental sustainability food labels considering in particular ecological footprints for carbon emission and water usage. Carbon emission and water usage are credence characteristics that can usually not be verified by the consumer at the point of purchase (Darby & Karni, 1973). One way to turn such credence quality attributes into search quality attributes (that can be perceived by consumers) is the use of environmental sustainability labels, which provide footprint information. However, there is a distinction between different labelling schemes. While consumers nowadays are relatively familiar with labels such as the nutrition facts panel, they are rather unfamiliar with the primary unit of carbon labelling, lacking commonplace experience that would enable them to contextualize CO_2 equivalents (e.g., Hartikainen, Roininen, Katajajuuri, & Pulkkinen, 2014; Van Loo, Caputo, Nayga Jr, & Verbeke, 2014). The level of consumer awareness and

understanding related to carbon labelling therefore more closely resembles that found in eco-labelling (e.g.,Teisl, 2003) or ethical labeling, rather than in nutritional labelling (Upham, et al., 2011). Interestingly, studies usually find a high degree of self-reported use of nutrition labels but only a low observed use of nutrition labels (Grunert, Fernández-Celemín, Wills, Storcksdieck genannt Bonsmann, & Nureeva, 2010).With regard to environmental labels, consumers generally report not using them in the first place (Grunert, et al., 2014). This raises the question of whether labels carrying specific information, such as carbon and water footprints, could be an alternative to more general environmental labels in order to support sustainable consumer behavior.

The literature on environmental sustainability labels has improved understanding of various different drivers that may lead consumers to choose such labels and corresponding products. Schumacher (2010) has shown that consumers' stated preferences for eco-labelled goods increase with environmental consciousness and decrease with price-orientation. Some studies have linked individuals' values to their preferences for footprint labeled foods (e.g.,Grebitus, Steiner, & Veeman, 2013; Grebitus, Steiner, & Veeman, 2015). Kempton (1991) demonstrates that consumers' desire to preserve the environment for one's descendants is a key concern to U.S. consumers when choosing products carrying eco-labels. However, knowledge levels and understanding of environmental labels have been found to be low, which could deter adoption of these labels when making food choices (Grunert, et al., 2014). To address this issue, we investigate consumer sustainability knowledge, namely subjective and objective knowledge as well as usage experience.

Carbon and Water Footprint Labelling

Consumer preferences for water usage footprints have been investigated for various products and markets, including global cotton consumption (Chapagain, Hoekstra, Savenije, &

Gautam, 2006), coffee and tea (Chapagain & Hoekstra, 2007), pork (Galloway, et al., 2007), tomatoes (Chapagain & Orr, 2009), as well as pasta sauce and candy (Ridoutt & Pfister, 2010), suggesting widespread interest in the application of this labelling concept. Research related to carbon labelling includes a food-based labelling survey of Japanese undergraduate students (Kimura, et al., 2010), suggesting that willingness to pay is higher if information has to be obtained actively. Recent carbon label studies have been conducted on locally grown fresh apples, applying an equilibrium displacement model on US consumer responses to labels (Onozaka, Hu, & Thilmany, 2015), and a double bounded dichotomous choice analysis for fluid milk and bread in Chile (Echeverría, Moreira, Sepúlveda, & Wittwer, 2014). Closest to our analysis are two articles that focus on the power of human values to predict Canadians' choices of unprocessed ground beef products labelled for environmental footprints (Grebitus, Steiner, et al., 2013), and Germans' choices of potatoes labeled for environmental footprints related to human values and trust (Grebitus, et al., 2015). Although those articles also employ attribute-based choice experiments, they differ from this analysis in focusing on only one country and one product, while considering only individuals' value orientation and trust, rather than focusing on the role of other psychometric variables and assessing groupings of consumers with similar preferences as consumer segments. Our focus on the two selected countries and staple foods was primarily motivated by our goal to analyze the robustness of our predictions, irrespective of the cultural background of the respondents. Furthermore, in contrast to the previous studies, which conducted multinomial and mixed logit analyses, we use latent class analysis to identify distinct segment classes based on choice behavior and psychometric variables. The results can be used to infer recommendations for marketers to target potential customers and policy makers to develop socio-economic policies related to ecological issues.

Consumer Knowledge

We focus on consumer knowledge in this paper, assessing the relationship between preferences for environmental labeling and three aspects of consumer knowledge: subjective knowledge (i.e., what individuals think they know), objective knowledge (i.e., what is actually memorized) and usage experience (Brucks, 1985; Carlson, Vincent, Hardesty, & Bearden, 2009; Lee & Lee, 2009; Raju, Lonial, & Glynn Mangold, 1995).

Previous work has shown that subjective knowledge affects the quality of consumers' choices (e.g., Moorman, Diehl, Brinberg, & Kidwell, 2004). Consumers make an effort to achieve consistency between subjective and objective knowledge such that objective knowledge increases the likelihood that consumers will locate themselves close to stimuli consistent with their subjective knowledge (Moorman, et al., 2004). This leads to substantial correlation between both types of knowledge (Brucks, 1985; Raju, et al., 1995), although this was found to be stronger for products relative to non-products (e.g., financial or medical services) and public relative to private goods (Carlson, et al., 2009). Divergence between subjective and objective environmental knowledge has been observed, with subjective knowledge having more influence on actual environmental behavior (Aertsens, Mondelaers, Verbeke, Buysse, & Van Huylenbroeck, 2011; Ellen, 1994). In contrast, early adoption of new labels, such as carbon or water footprint labels, was attributed more to objective knowledge (Thøgersen, Haugaard, & Olesen, 2010), leading us to assess both types of knowledge in this study. Improving knowledge in general by educating consumers with regard to carbon footprint information was shown to increase intentions to purchase products with a lower carbon impact (Wikoff, Rainbolt, & Wakeland, 2012).

The role of knowledge has also been assessed in the context of the nature of product attributes, distinguishing extrinsic (e.g., price) from intrinsic (e.g., functional) attributes, and was found to play a significant role in consumer decision making (Park & Lessig, 1981; Raju,

et al., 1995; Rao & Monroe, 1988). Rao and Sieben (1992) have identified a U-shaped relationship between knowledge and extrinsic/intrinsic attributes, suggesting that with increasing levels of knowledge, importance of extrinsic attributes first decreases, then subsequently increases relative to intrinsic attributes. In the context of our analysis, we focus on consumers' preferences for the key extrinsic attribute (price) relative to the attribute which is the major functional aspect of the products under consideration, namely their carbon and water footprint levels. Therefore we are most interested in benchmarking our findings with those of Rao and Sieben (1992), who find that low-knowledge consumers place a greater weight on extrinsic attributes relative to intrinsic ones, as well as with Raju et al. (1995), who suggest that high-knowledge consumers may attend to both intrinsic and extrinsic attributes in a more balanced fashion than consumers with lower levels of knowledge.

Previous work has also assessed the role of consumer knowledge in the context of usage experience, in particular, relative to consumers' previous environmentally friendly behavior and the lifestyle characteristics associated with such behavior (e.g., Ellen, Wiener, & Cobb-Walgren, 1991; Thøgersen, et al., 2010). In particular, consumers who had previously purchased environmentally friendly products were observed to show a greater likelihood of choosing products with lower carbon and water footprints (Thøgersen, et al., 2010). Similarly, consumers who were members of environmentally active groups were found to be more likely to choose products with lower carbon and water footprints (e.g., Ellen, et al., 1991). Further, in their cluster analysis of a survey that asked U.S. respondents to recall a recent opportunity to purchase a green product, Gleim, Smith, Andrews and Cronin Jr (2013) found that one of the main barriers to green consumption is consumers' lack of shopping expertise (perceived understanding about green products).

Against this background, this study aims to assess the impact of these three types of knowledge on environmentally sustainable choices via four hypotheses:

Our **first hypothesis** is that higher levels of subjective and objective knowledge increase the likelihood to choose products with lower carbon and water footprints, because both subjective and objective knowledge increase consumers' ability to assess and select products (Moorman, et al., 2004) .[1]

To benchmark our work to previous analyses, our **second hypothesis** is that subjective and objective knowledge have a different effect on consumers' decision making associated with footprint labeling. More specifically, our second hypothesis is that subjective knowledge is more important in driving environmentally sustainable choices than objective knowledge (Aertsens, et al., 2011; Alba & Hutchinson, 1987; Moorman, et al., 2004).[2]

Considering usage experience (Brucks, 1985; Raju, et al., 1995) regarding previous environmentally sustainable purchases (Thøgersen, et al., 2010) and membership in environmental groups (e.g., Ellen, et al., 1991), our **third hypothesis** is that consumers who are characterized by higher levels of such usage experience are more likely to choose products with lower carbon and water footprints (Ellen, et al., 1991; Thøgersen, et al., 2010).

Benchmarking our analysis to Raju et al. (1995), our **fourth hypothesis** is that high-knowledge consumers weigh intrinsic and extrinsic attributes more evenly than consumers with lower knowledge levels.

Methods

Sample description

This study applies data from two online surveys—Grebitus et al. (2013) and Grebitus et al. (2015) have used these surveys in the past—one conducted in Canada between December 2010 and February 2011 and a second similar survey applied in Germany between December

[1] The authors argue that subjective knowledge can influence decision making by increasing the likelihood that consumers will search in locations consistent with subjective knowledge (Moorman, et al., 2004).
[2] Moorman et al. (2004, p. 674) suggest that it is not necessary to have objective knowledge to act consistently.

2011 and January 2012. Our aim was to compare responses from North America to responses from Europe. While both, Canada and Germany, are developed countries, they differ in features of their economic structure, history and culture. Germany, the largest economy in Europe in GDP terms, is a major exporter of finished and industrial goods, with much less dependence on fossil fuel use domestically than Canada, which has a smaller population, a larger land base, and a high dependence on the export of raw materials and fossil-fuel based energy. In this paper, we use the data of a set of questions that asked respondents to indicate their knowledge and usage experience relative to environmental issues and products, and related this to respondents' choices of two staple food products. These staple products, namely ground beef and potatoes, were chosen since there are considerable differences in carbon emissions and water usage between different groups of food such as meats and vegetable produce.

The survey was pretested with an initial focus group comprised of 14 randomly recruited adult members of the public in Edmonton, Canada. Data were subsequently collected by an international marketing company. This company was responsible for sample recruitment in both countries and charged with collection of a reasonably representative sample of adult grocery buyer respondents in each case. Surveys were completed by n=1551 participants in Canada and n=1579 participants in Germany. An overview of the demographic characteristics of the two samples is provided in Table 1. The share of female participants is 52% in the Canadian sample and 55% in the German sample. On average, Canadian respondents were 48 years old and the average age of German participants was 45 years, relative to an average age of 41 years for the total Canadian population, indicated by the 2011 Census of Canada (Statistics Canada, 2011) and an average of 44 years from the 2011 German Census (Statistisches Bundesamt, 2014). Household size ranged from 1 to 9 individuals in Canada (Mean=2.5) and from 1 to 7 individuals in Germany (Mean=2.2),

243 which compares to a mean census household size of 2 in both countries (Statistics Canada,
244 2011). In both countries at least one child was present in approximately 20% of the
245 households in the sample. Roughly one third of respondents in both the Canadian and
246 German samples held a university degree. Consequently the Canadian sample is slightly more
247 highly educated than the total Canadian population: in 2011 some 26% of Canadian adults
248 aged 25 to 65 held a university degree, according to Canada's National Household survey
249 (Statistics Canada, 2015a, 2015b). The German sample is also slightly better educated than
250 the German population (German statistical office year 2005). Average annual household
251 income before taxes reported for respondents was CAD $42,500 (Canada) or 28,000 Euros
252 (Germany), whereas the respective 2012 census gross household income in Germany is 3,989
253 Euro/month (Destatis, 2015) and the median after-tax household income for all households
254 was CAD $47,100 in 2010 (Statistics Canada, 2011).

Table 1. Socio-demographic characteristics of the two samples

	Canada	Germany
n	1551	1579
Female	52 %	55 %
Age groups		
18-24	5.8 %	4.9 %
25-34	16.8 %	20.9 %
35-44	18.3 %	24.8 %
45-54	23.9 %	25.2 %
55-64	23.4 %	17.3 %
65-74	9.5 %	6.0 %
>74	2.2 %	0.9 %
Education*		
Volks-/Hauptschule (low school education)	N/A	13.8 %
Mittlere Reife (modest school education)	N/A	31.3 %
High School Diploma (Germany: University entrance diploma, i.e., high school education)	22 %	21.5 %
University degree	N/A	29.4 %
Some college	22 %	N/A
Technical School Diploma	17 %	N/A
Bachelor's Degree	24 %	N/A
Master's Degree	7 %	N/A
Doctorate	1 %	N/A
Other	7 %	N/A
Mean household size	2.5	2.2
Households with at least one child under 12 years of age	20.1 %	18.9 %
Average annual household income	€ 30,421[3]	€ 28,000

Note: *Germany and Canada differ in their education systems. Therefore, education levels were measured based on country specifications.

Choice experiments

In the following empirical analysis, we use data from attribute-based choice experiments (Louviere, Hensher, Swait, & Adamowicz, 2000). By presenting respondents with a set of product choice alternatives, described in terms of product attributes, the preferred product choices allow attribute preferences to be revealed without directly asking participants about their subjective valuation of specific product attributes. This approach reduces social desirability bias (Norwood & Lusk, 2011), which can be expected to be an issue in investigations of green consumer behavior, given increasing societal awareness of this topic.

[3] We assume an exchange rate of 0.7158 CAD/Euro.

Since there are considerable differences in carbon emissions and water usage between different groups of food such as meats and produce, we consider two staple foods, ground beef and potatoes. In the choice experiments, participants could choose between different product options described by combinations of three attributes, price, carbon emission equivalents and water usage. Each attribute has three levels (Table 2) which were randomly varied among the choices presented to participants. The figures that are presented as carbon emission equivalents and water usage measures are based on estimates from previous research (see e.g., Chapagain & Hoekstra, 2004). To identify the prices used in the experiment we collected actual market prices for ground beef and potatoes at different grocery stores in a major city in each of the two countries chosen for the study (Edmonton, Canada and Bonn, Germany). Based on these observations we identified price levels based on an assessment of the mean price, in addition to plus and minus one standard deviation (see e.g.,Grebitus, Jensen, Roosen, & Sebranek, 2013).[4]

Table 2. Design of Choice Experiments (prices in Euro for Germany and in CAD $ for Canada)

	Product	Quantity	Price	Carbon emission	Water usage	Categorical level
Levels	Ground beef	1 kg	5.19 € /CAD$ 6.75	19.49 kg	13175 l	Low
			6.11 € /CAD$ 7.95	22.93 kg	15500 l	Medium
			7.02 € /CAD$ 9.14	26.37 kg	17825 l	High
	Potatoes	1 kg	0.72 € /CAD$ 1.63	0.51 kg	173.66 l	Low
			0.85 € /CAD$ 1.92	0.60 kg	204.30 l	Medium
			0.98 € /CAD$ 2.20	0.69 kg	234.95 l	High

A random parameter panel efficient design with 20 choice sets was generated using Ngene software (Choice Metrics, 2014). We used a block design with 10 blocks containing

[4] It should be noted that the point of sale prices we collected were for products that were not labelled for water usage or carbon emission equivalents.

two choice sets each to avoid fatigue effects, where a given respondent was randomly assigned to one block for each product category.[5] Each choice set consisted of three alternatives: alternative A, alternative B and the "no choice" option of choosing "None of These" (allowing opting-out). The order of presentation and allocation to respondents of the various choice sets was randomized. Figure 1 presents an example choice set.

Figure 1 Example choice set in the Canadian survey

Imagine you are in your usual grocery store and you would like to purchase 1 kg of ground beef you usually buy: Do you choose Alternative A, Alternative B or Alternative C?

1 kg of ground beef	Alternative A	Alternative B	Alternative C
Carbon (CO_2) emission equivalents	22.93 kg	26.37 kg	None of these
Water usage	13175.00 l	13175.00 l	
Price	6.75 CAD $	9.14 CAD $	
I would choose:			

In line with similar work (e.g., Grebitus, Lusk, & Nayga Jr, 2013), carbon emission and water usage were described prior to the choice experiments to provide a common definition of the concepts:

"Carbon emission equivalents are the amount of Carbon Dioxide (CO2) created by the grocery product and refer to greenhouse gas emissions over the whole life of a product. [For example, from the time an apple was grown and picked from a tree until its presentation at

[5] Since this study was part of a larger project, there were four product categories in total. Here, we report results on ground beef and potatoes; two product categories tested (a household essential and dairy) are not reported on.

the point of sale, e.g., in a supermarket]. The lower the emissions, the better for the environment."

"Water usage refers to the water used to produce, store and distribute a grocery product. [For example, the water used in the orchard to grow an apple until it is picked from a tree and then until its presentation at the point of sale, e.g., in a supermarket]. The lower the water usage, the better for the environment."

Knowledge assessment

To assess respondents' *subjective knowledge*, questions were asked on how well informed respondents considered themselves to be about various ways to reduce greenhouse gas emissions, climate friendly food production, and carbon footprint in production, as well as water usage in production, prior to the experiment. Each item was rated on a scale ranging from 1 = no knowledge, to 5 = very knowledgeable, similar to Grebitus, Jensen, Roosen and Sebranek (2013). These values were averaged for each participant to create a "subjective knowledge index" intended to measure subjectively perceived knowledge (e.g., Flynn & Goldsmith, 1999).

To assess *objective knowledge*, participants were asked, after completion of the choice experiments, to indicate the extent of their agreement with four statements about climate friendly production, water usage and carbon footprint, using a scale ranging from 1 = do not agree, to 5 = fully agree. Responses were re-coded and averaged for each participant to create an "objective knowledge index". Table 3 displays the statement items used in the questionnaire.

We separated the assessment of subjective and objective knowledge in order to prevent carryover effects between the two concepts. Subjective knowledge was, therefore, assessed in the earliest part of the survey, while objective knowledge was assessed upon

completion of the choice task as part of a general questionnaire component about knowledge and lifestyle factors. The statements to assess objective knowledge were developed to not closely resemble the definitions, so as to prevent simple recall of the definitions. Instead, the items were designed to require some transfer of knowledge, so that these could only be answered correctly if the concept was understood.

Table 3. Statements used to assess objective knowledge about climate friendly production

1. Climate friendly products are those products that are low in water usage.
2. Carbon footprint and ecological footprint are the same.
3. A carbon footprint measures the amount of CO2 emitted in producing, distributing and marketing the product.
4. Climate friendly products are those products that are high in carbon emissions

Note: Items were rated on a 5-point scale, where 1 = do not agree and 5 = fully agree. Items 2 and 4 were reversed to calculate the index.

To assess *usage experience*, we explored whether participants pursue climate friendly shopping behavior by asking whether they had purchased any climate friendly grocery products in the last four weeks. In addition, we controlled for whether or not the respondent was a member of a group that supports the environment.

Latent class choice analysis

Latent class models draw on the assumption of finite mixture modelling, i.e., instead of assuming one homogeneous population, it is assumed that a mixture of unobserved segments exists in a population (e.g.,Wedel & Kamakura, 2000). These segments are characterized by segment-specific sets of identifiable parameters. In latent class choice experiments it is assumed that the utility an individual derives from a certain attribute is not individual-specific

but depends on the unobservable class membership to one of $q = 1,2\ldots Q$ latent classes. The probability of class membership q depends on individual i choosing alternative j at time t, which consists of a certain set of observable attributes x' (Greene & Hensher, 2003):

$$(1)\quad Prob_{jit|q} = \frac{\exp(x'_{it,j}\beta_q)}{\sum_{j=1}^{Ji}\exp(x'_{it,j}\beta_q)}$$

It is assumed that there exist a total of Q latent preference classes, which results in the overall log-likelihood:

$$(2)\quad lnL = \sum_{i=1}^{N} ln\left[\sum_{q=1}^{Q} C_{iq}\left(\prod_{t}^{T_i} Prob_{jit|q}\right)\right]$$

with C_{iq} being the probability that individual i belongs to class q. While this allows segmenting a population based on the observed response pattern, these classes are not informative as to why the utility derived from the given attributes differs. In order to describe the latent classes with the consumer characteristics of interest, we follow the approach described by Boxall and Adamowicz (2002) to incorporate relevant psychometric constructs and socio-demographic characteristics to explain segment membership.

All product attributes entered the model as effects coded variables. Due to the different scaling of the environmental attributes and to ensure comparability of the price level between countries we opted for categorical variables instead of linear effects. The underlying utility function we assume is as follows:

$$(3)\quad U_{ijt|q} = \beta_{CO2|q}\, CO2_{ijt} + \beta_{H2O|q}\, H2O_{ijt} + \beta_{p|q}\, P_{ijt} + \mathcal{E}_{ijt|q},$$

where CO2 is the level of carbon emission, H2O is the level of water usage and P denotes the price level; $\mathcal{E}$ is the error term and subscripts follow the definitions above.

Empirical results

Descriptive statistics

Table 4 provides descriptive statistics for the postulated independent variables included in the analysis. It is evident that both Canadian and German participants tend to view themselves as moderately knowledgeable (subjective knowledge). Participants' objective knowledge ranges around a value of 3.5, also indicating a moderate objective knowledge level.[6] The measured constructs were only mildly correlated, with a significant Pearson correlation coefficient of r = .11 for Germany and r = .17 for Canada. Regarding usage experience, the percentage of respondents who claim to buy climate friendly products is twice as high in Germany, with 35 % of the total, compared to 17% in Canada. An opposite tendency is observed regarding membership in an environmental group. Only 8 % of the German respondents reported being a member, while such membership was reported for 12 % of the Canadian sample.

Table 4. Descriptive statistics of relevant consumer characteristics

		Canada (n=1552)	Germany (n=1579)
Index: subjective knowledge[7]	Mean (SD)	2.46 (0.90)	2.54 (0.86)
Index: objective knowledge[8]	Mean (SD)	3.59 (0.52)	3.53 (0.55)
Shop climate friendly	% yes	17	35
Member of environmental group	% yes	12	8

Econometric results

All models were estimated using Latent Gold Choice 4.5 software. An aggregate multinomial logit (MNL) model was estimated to serve as a reference model for each country and product category. As shown in Table 5, all choice attributes of the model – price, carbon and water

[6] Since we provided information regarding the meaning of high and low carbon emission and water usage, respectively, this figure might be higher than had respondents not received such information.
[7] The Cronbach's alpha for the Canadian sample was 0.89, and for the German sample it was 0.86.
[8] We do not apply and report Cronbach's alpha values for objective knowledge because it is a formative, not reflective construct

386 footprint – were significant, suggesting that each was relevant in the decision process.
387 Inclusion of the no choice option in the model improved model fit substantially in all
388 models.[9] Relative attribute importance was included as measure of the importance of an
389 attribute in the respondent's decision. It is calculated as the ratio of the utility of an attribute
390 to the sum of the utility of all attributes (Kallas, Realini, & Gil, 2014; Vermunt & Magidson,
391 2005). It therefore follows that attributes with a high coefficient will have a higher relative
392 attribute importance. For the no choice option, this could result in a higher attribute
393 importance relative to the other available choices, even if the no choice option was not
394 chosen, or in other words if participants derived utility from *not* choosing the no choice
395 option. The ratio was highest for price, which explained 27 % to 47 % of variance in
396 respondents' choices. Carbon emissions explained between 12 % and 23 %. Water usage
397 explained 24% to 30 % of variance for both countries. The no choice option was of almost no
398 relevance for German respondents' stated ground beef choices, but explained about 25 % of
399 the variance of stated choices for potatoes in both countries.
400
401 *General results of latent class modelling*
402 To benchmark findings across the two countries, in this section we describe the results for the
403 Canadian sample in more detail and refer to the German sample only where results deviated.
404 Empirical results of the latent class modelling are presented in Table 6 for the Canadian
405 sample and Table 7 for the German sample. In addition, Figure 2 summarizes the relative
406 importance of attributes for each of the product categories and countries.

[9] The no choice option was chosen in 18 % of the ground beef and 7 % of the potato choices in the Canadian sample, and in 26 % of the ground beef and 9% of the potato choices in the German sample.

407 **Table 5. Aggregated MNL choice models for both countries and product categories**

408

		Canada						*Germany*					
Model for Choices		***Ground beef***			***Potato***			***Ground beef***			***Potato***		
Pseudo-R^2		0.21			0.29			0.14			0.21		
n		1552			1552			1579			1579		
Attributes		*Class1*	*Wald*	*Importance*	*Class1*	*Wald*	*Importance*	*Class1*	*Wald*	*Importance*	*Class1*	*Wald*	*Importance*
CO2	Low	0.52***	155.33***	18%	0.49***	123.58***	12%	0.57***	195.95***	23%	0.64***	245.67***	19%
	Medium	-0.17***			-0.18***			-0.18***			-0.19***		
	High	-0.35***			-0.31***			-0.39***			-0.45***		
H2O	Low	0.69***	176.67***	24%	1.05***	366.98***	29%	0.73***	217.44***	30%	1.04***	369.37***	28%
	Medium	-0.19***			-0.16***			-0.24***			-0.45***		
	High	-0.50***			-0.88***			-0.50***			-0.59***		
Price	Low	1.24***	720.97***	47%	1.28***	716.36***	36%	1.03***	537.53***	43%	0.85***	414.56***	27%
	Medium	-0.10*			-0.17***			-0.23***			-0.15***		
	High	-1.13***			-1.12***			-0.79***			-0.70***		
No choice option		-0.28***	128.47***	11%	-0.81***	528.66***	23%	-0.08***	13.90***	4%	-0.77***	549.34***	26%
		LL = -2689.57, AIC(LL) = 5393.15, AIC(LL)/N = 3.48, BIC(LL) = 4727.23, BIC(LL)/N = 3.05			LL = -2226.28, AIC(LL) = 4466.56, AIC(LL)/N = 2.88, BIC(LL) = 4503.99, BIC(LL)/N = 2.90			LL = -3022.02, AIC(LL) = 6058.05, AIC(LL)/N = 3.84, BIC(LL) = 6095.60, BIC(LL)/N = 3.86			LL = -2474.37, AIC(LL) = 4962.75, AIC(LL)/N = 3.14, BIC(LL) = 5000.3, BIC(LL)/N = 3.17		

Note: *p<0.05; **p<0.01; ***p<0.001

409 **Table 6. Latent class models for both product categories, Canadian sample**

Model for Choices		***Ground beef***					***Potato***				
		Class1 *Price sensitive*	*Class2* *Open to environmentalism*	*Class3* *Avid environmentalist*	*Class4* *Low knowledge*	*Overall*	*Class1* *Price sensitive*	*Class2* *Avid environmentalist*	*Class3* *Open to environmentalism*	*Class4* *Low knowledge*	*Overall*
	Absolute size	869	264	248	171	1552	931	404	140	78	1552
	Relative size	56%	17%	16%	11%		60%	26%	9%	5%	
	R^2	0.68	0.06	0.49	0.36	0.75	0.74	0.54	0.06	0.55	0.77
Attributes		*Class1*	*Class2*	*Class3*	*Class4*	*Wald*	*Class1*	*Class2*	*Class3*	*Class4*	*Wald*
CO2	Low	1.47***	4.19*	1.61***	-1.05***	136.30***	0.75***	1.51***	0.36	0.31	101.27***
	Medium	-0.33	0.26	-0.16	0.39		2.23*	-0.25	0.30	-2.01*	
	High	-1.14***	-4.45	-1.45***	0.66**		-2.98*	-1.27***	-0.67*	1.70*	
H2O	Low	2.19***	3.45*	0.83**	-0.31	114.06***	3.96**	2.85***	0.18	-2.31*	73.52***
	Medium	-0.14	-1.34	-0.43*	0.55**		0.07	-0.31*	0.44*	0.18	
	High	-2.04***	-2.11*	-0.40	-0.24		-4.03**	-2.54***	-.62*	2.13*	
Price	Low	4.21***	1.51		1.05***	156.64***	7.65**	0.67***	0.60**	-1.10	33.86***
	Medium	-0.60***	1.61		-0.03		-0.37*	0.20	0.26	-2.22*	
	High	-3.60***	-3.12*		-1.02***		-7.28**	-0.87***	-0.86**	3.33*	
No choice option		-1.16***	3.32**	-2.09**	-0.78***	193.95***	-2.54***	-3.49	1.07***	-4.49	139.12***
Model for Classes											
Intercept		-1.44**	-1.43**	-2.63***	5.49***	21.12***	0.48	-2.66***	-0.25	2.43*	17.24***
Index: subjective knowledge		-0.21**	0.11	0.12*	-0.02	12.62**	-0.22***	0.10	0.09	0.02	11.22**
Index: objective knowledge		0.79***	0.31*	0.66***	-1.77***	32.46***	0.37**	0.90***	-0.14	-1.13***	30.06***
Female		-0.10*	0.08	0.04	-0.02	5.50	-0.06	0.33***	0.15*	-0.43***	20.87***
Shop climate friendly		-0.42***	-0.13	0.30**	0.25*	20.00***	-0.26**	0.23*	-0.27*	0.30*	23.28***
Member environmental group		0.00	0.09	0.07	-0.15	1.08	0.03	0.20	0.16	-0.38	3.15
		LL = -2169.48, AIC(LL) = 4426.97, AIC(LL)/N = 2.85, BIC(LL) = 4662.25, BIC(LL)/N = 3.00, pseudo-R^2 = 0.75					LL = -1832.22, AIC(LL) = 3829.87, AIC(LL)/N = 2.47, BIC(LL) = 4002.41, BIC(LL)/N = 2.58, pseudo-R^2 = 0.73				

Note: *p<0.05; **p<0.01; ***p<0.001. Classes are ordered by size, not by name.

410

411 **Table 7. Latent class models for both product categories, German sample**

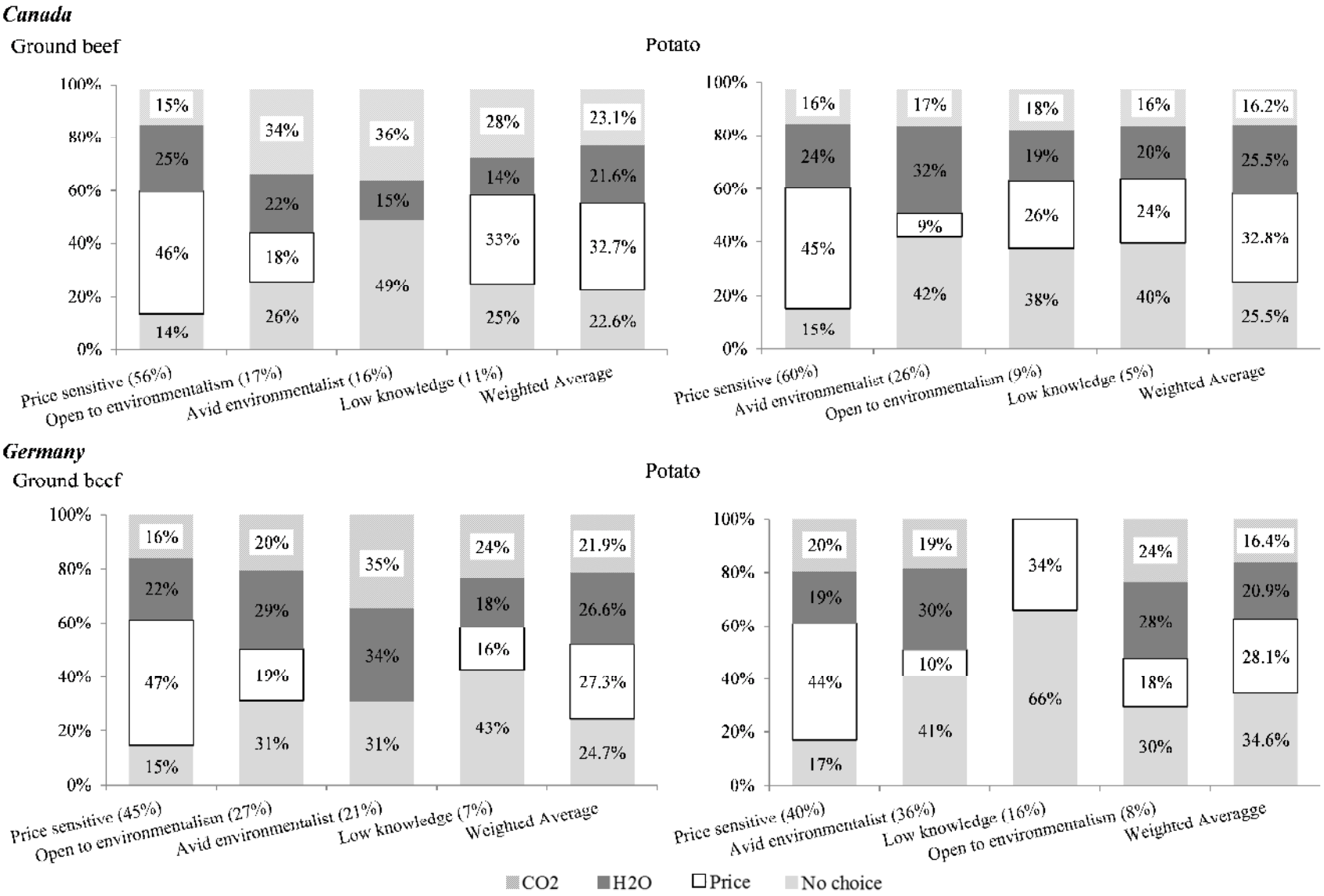
Model for Choices		***Ground beef***					***Potato***				
		Class1	*Class2*	*Class3*	*Class4*	*Overall*	*Class1*	*Class2*	*Class3*	*Class4*	*Overall*
		Price sensitive	*Open to environmentalism*	*Avid environmentalist*	*Low knowledge*		*Price sensitive*	*Avid environmentalist*	*Low knowledge*	*Open to environmentalism*	
	Absolute size	711	426	332	111	1579	632	568	253	126	1579
	Relative size	45%	27%	21%	7%		40%	36%	16%	8%	
	R^2	0.64	0.06	0.53	0.65	0.75	0.78	0.67	0.05	0.07	0.70
Attributes		*Class1*	*Class2*	*Class3*	*Class4*	*Wald*	*Class1*	*Class2*	*Class3*[b]	*Class4*	*Wald*
CO2	Low	1.30***	1.19***	1.78***	-2.77***	185.64***	0.77*	2.78***		1.18*	65.64***
	Medium	-0.27	-0.13	-0.33*	1.28**		3.20**	-0.18		-0.06	
	High	-1.03***	-1.06***	-1.45***	1.49**		-3.97**	-2.60***		-1.12*	
H2O[a]	Low		1.70***			170.41***	4.25***	4.86***		1.52*	71.51***
	Medium		-0.20**				-1.40***	-0.95***		-1.20*	
	High		-1.51***				-2.86***	-3.91***		-0.32	
Price	Low	3.64***	0.91***		0.97**	210.37***	7.78***	0.24	0.28*	0.22	55.97***
	Medium	-0.61***	0.30		0.85*		0.61***	1.33**	-0.53**	0.76*	
	High	-3.02***	-1.21***		-1.82***		-8.39***	-1.57***	0.24	-0.98*	
No choice option		-1.05***	1.72***	-1.44***	-3.84*	621.45***	-3.11***	-5.92*	-0.78***	1.43***	114.66***
Model for Classes											
Intercept		-0.36	0.42	-1.67**	1.61*	10.90**	-0.41	-1.72***	3.06***	-0.93	16.23***
Index: subjective knowledge		-0.11	-0.10	-0.02	0.22	2.89	-0.17*	-0.02	0.22*	-0.03	6.83
Index: objective knowledge		0.33**	0.08	0.51***	-0.92***	16.30***	0.35**	0.64***	-1.09**	0.11	32.30***
Female		-0.07	0.10*	0.19**	-0.21	10.69**	-0.20***	0.10	0.07	0.03	11.35**
Shop climate friendly		-0.39***	-0.12*	0.37***	0.15	43.86***	-0.38***	0.51***	-0.04	-0.09	61.82***
Member environmental group		-0.23*	0.06	-0.10	0.27*	5.24	-0.15	-0.26*	0.18	0.23*	8.89*
		LL = -2458.76, AIC(LL) = 4993.51, AIC(LL)/N = 3.16, BIC(LL) = 5197.368, BIC(LL)/N = 3.280, pseudo-R^2 = 0.75					LL = -2058.90, AIC(LL) = 4201.80, AIC(LL)/N = 2.66, BIC(LL) = 4427.11, BIC(LL)/N = 2.80, pseudo-R^2 = 0.70				

Note: *p<0.05; **p<0.01; ***p<0.001; Classes are ordered by size, not by name.

[a] Coefficients for H2O were restricted to be equal across segments for ground beef; [b] Coefficients for CO2 and H2O were restricted to 0 for Class 3 for potatoes

412

413 **Figure 2 Relative importance of attributes for each of the product categories and countries**



414

415 Note: Relative class sizes are displayed in parentheses following the class name. Classes are ordered by size, not by name.

For both samples and products, a four-class model fitted the data best in terms of model selection criteria and fit statistics (Table 6 & 7). In the case of ground beef, for the Canadian sample, there were no significant differences between attribute levels for price in class 3, leading us to constrain these parameters to zero. This reduced the BIC value from 4672.62 to 4662.25 and increased the pseudo from R^2 0.74 to 0.75. The model of potato choices did not have to be further constrained for the Canadian sample. For the German sample, the coefficients for water usage in the ground beef model did not differ between classes, so we constrained these to be equal in order to improve model fit from a BIC of 5242.34 to 5197.37. For class 3 potato choices, there were no significant differences for the attribute levels of the two environmental attributes, consequently these coefficients were constrained to zero, reducing the BIC from 4466.04 to 4427.11.

Overall, latent class modelling improved model fit for both product categories and countries relative to the baseline MNL models. For all non-constrained attribute levels, the Wald statistic confirmed significant differences both between attribute levels as well as between latent classes. As can be seen from Table 6 and Table 7, participants overall preferred low prices and low values of the environmental attributes. In the following we first describe results for ground beef choices and then for potato choices. In both cases we describe results for Canada in-depth and then point out similarities and differences between Canada and Germany.

Ground beef choices

For **ground beef**, the largest class comprised 56 % of respondents, which we label the "*price sensitive class*". Members of this class 1 derived the highest utility from the lowest price level and disutility from the two higher price levels. Participants in this class were more likely to report feeling less knowledgeable, compared to the other classes, as indicated by the negative

coefficient of the subjective knowledge index. However, they were more likely to score high on the objective knowledge questions as indicated by the significant positive coefficient of the objective knowledge index. These consumers also preferred the environmentally friendlier option, lending support to *hypothesis one* that knowledge increases green choices as primarily indicated by the positive coefficient for objective knowledge. However, low prices were even more important for participants in this class, suggesting that a high level of objective knowledge is not sufficient to buy green products irrespective of price. The negative coefficient on subjective knowledge lends support to *hypothesis two* indicating that subjective knowledge is more important for behavior than objective knowledge. Unsurprisingly, participants in this price-sensitive class were less likely to state that they had bought climate friendly products in the last four weeks, thus scoring low on usage experience. Male respondents were slightly overrepresented in class 1.

Table 6 shows further that the second largest class (17 % of respondents) derived highest utility from the lowest levels of environmental attributes and preferred other attributes and attribute-level combinations (the "no choice" option). Members of class 2 were more likely to derive disutility from the highest price level, but were indifferent towards the two lower price levels, indicating members of this group are less price sensitive than those in the first segment. This segment could be described as *"open to environmentalism"*, since they score high on the objective knowledge index, relative to the two remaining segments, were less price sensitive and gained utility from low footprint levels.

The third largest class, accounting for 16 % of the sample, could be considered as "*avid environmentalist*." Class 3 members derived high utility from the lowest levels of the environmental attributes of carbon and water use, and prices did not play a significant role in

462 their stated choices for the beef product. Members of this class were more likely to claim to have
463 shopped for environmentally friendly products, to have high subjective knowledge and to score
464 high on the objective knowledge questions. This group seems to be ready to adopt a carbon and
465 water footprint label to guide environmentally responsible choices. With regard to *hypothesis*
466 *four*, we would have expected participants in this class to weigh extrinsic and intrinsic attributes
467 evenly, which is, however, not the case. Price, an extrinsic attribute, was mostly ignored for
468 ground beef choices by those in this class.

469 The smallest class 4, which represented 11 % of the sample, appeared to derive utility
470 from high levels of carbon emission and medium levels of water use. Class 4 was characterized
471 by a negative coefficient for the objective knowledge index. Participants in this group, termed
472 the "*low knowledge*" class, stated that they shop for climate friendly products; however, this is
473 contradicted by the stated choices that they made, which were indeed for the less climate friendly
474 options. It is possible that consumers in this group misinterpreted the environmental label
475 specifications, or wanted to signal a greater environmental consciousness than is actually the
476 case, by over-stating their past environmentally-friendly shopping behavior.

477 Overall, Figure 2 shows that price was the most important attribute for Canadian
478 consumer ground beef choices in the "*price sensitive*" class, accounting for 46 % of variance.
479 For the "*open to environmentalism*" class, the environmental attributes accounted for 56% of
480 variance. The next largest segment of "*avid environmentalist*" made their decisions irrespective
481 of price. For the "*low knowledge"* segment, price was the most important attribute, accounting
482 for 33 % of variance.

483 Table 7 and Figure 2 show that generally the same classes applied for the German
484 sample, however, this sample included a smaller share of "*price sensitive"* consumers and a

485 considerably higher share of both *"open to environmentalism"* and "*avid environmentalist*"
486 consumers than the Canadian sample. This could have been expected from the higher share of
487 Germans that indicated shopping for climate friendly products and is also reflected in the
488 relatively more evenly balanced weighted average attribute importance shares in Figure 2. With
489 regard to the German classes, Figure 2 shows that price was the most important attribute for the
490 "*price sensitive"* segment, as expected. For both the *"open to environmentalism"* and "*avid*
491 *environmentalist*" segments, water usage is the most important attribute, a major difference
492 relative to the Canadian sample. The much smaller German "*low knowledge"* class is far less
493 price sensitive than is the Canadian "*low knowledge"* class. Overall, German consumers were
494 less price sensitive than the Canadian sample, which was not anticipated as GDP per capita is
495 higher in Canada than in Germany for the period under investigation.[10] Notably, for the German
496 sample, participants in the "*Low knowledge"* segment were more likely to indicate membership
497 of an environmental group, suggesting that this may not be a good proxy for environmental
498 behavior. Furthermore, the results suggest that usage experience is not closely related to
499 subjective and objective knowledge, as was also found in previous studies (Raju et al. 1995).

500 *Potato choices*

501 As shown in Table 6 and Figure 2, and as was the case for ground beef, participants
502 preferred low prices as well as low carbon emission and water usage values for their **potato**
503 choices. The largest segment for the Canadian sample was comprised of 60 % of the participants;
504 these derived highest utility from the lowest price level and disutility from the two higher price
505 levels. This "*price sensitive*" class also preferred the lowest carbon emission and water usage
506 levels, but to a smaller extent compared to price. Similar to the price-sensitive beef consumers,

[10] http://data.worldbank.org/indicator/NY.GDP.PCAP.CD

participants in this segment were more likely to indicate that they feel less knowledgeable about environmentally friendly products, even though they score high on the objective knowledge index. As with ground beef choices, in this class with low subjective knowledge, other attributes than carbon emissions and water usage are more important. Similar to the case of ground beef, *hypotheses one* and *two* are supported. In particular, regarding the second hypothesis, subjective knowledge appears to drive environmentally friendly behaviors (Aertsens, et al., 2011; Ellen, et al., 1991).

Participants in the second largest class for potato choices (26 % in this case) were *"avid environmentalist*." Class 2 members derived highest utility from low footprint values and placed less importance on price (Table 6 and Figure 2). Participants in this class were more likely than others to state that they shop for climate friendly products and were more likely to be female.

The third largest class (9 % of participants) showed a pattern for potato choices similar to class 2 beef choices (see Table 6). This group appeared to derive disutility from high footprint values (i.e., from less sustainable levels) and preferred low prices. It seems that this segment, with average levels of consumer knowledge, may try to evenly weigh extrinsic and intrinsic attributes as suggested by hypothesis four. Members of this segment were more likely to opt out of making a choice than those in the other segments, indicating that their preferences were not accommodated by the choice alternatives presented to them. They were less likely than those in other segments to state that they shop for environmentally friendly products. This suggests that even though they derived disutility from high carbon emissions and water usage, they have not adopted a habit of environmentally sustainable behavior. We therefore consider this class to be "*open to environmentalism*."

529 Similar to beef choices, we find a fourth class of "*low knowledge*" consumers who derive
530 utility from high footprint values and are likely to score low on the objective knowledge index.
531 Again in this class, participants were more likely to indicate shopping for climate friendly
532 products, suggesting that either this self-reported assessment is not a good indicator of climate
533 friendly behavior or that class members misinterpreted the footprint value characteristics.
534 As indicated by Figure 2, and similar to beef choices, price was the most important
535 attribute for the Canadian "*price sensitive*" segment. Interestingly, the "*price sensitive*" segment
536 is even larger than for beef choices. Price played a slightly greater role for the "*avid*
537 *environmentalist*" in the Canadian sample when deciding between potato choices relative to beef
538 choices, but the combined environmental attributes still account for 49 % of variance in this
539 segment. Also, for the *"open to environmentalism*" class, the combined environmental attributes
540 accounted for the larger share of explained variance (37 %), but price was more important than
541 for beef choices. Interestingly, for all classes, water usage was more important than carbon
542 emissions.
543 For the German sample, we found some of the same general patterns as for the Canadian
544 classes, although with a considerably smaller "*price sensitive*" and a larger "*avid*
545 *environmentalist*" segment than for the Canadian sample (Table 7 and Figure 2). Price was the
546 most important attribute for the "*price sensitive*" class as expected. Members of the "*avid*
547 *environmentalist*" class in the German sample were significantly less likely to be a member of an
548 environmental group than was the case for the Canadian group. The *"open to environmentalism"*
549 class was less price sensitive than the Canadian class—similar to the choices for beef. The
550 German "*low knowledge"* class was indifferent between carbon emission and water usage
551 values. Also, for the "*low knowledge"* German segment, the subjective knowledge coefficient

552 was positive, suggesting that self-judged (i.e., subjective) knowledge alone is unlikely to be
553 sufficient to make environmentally friendly choices (see Table 7).
554
555 **Discussion**
556 The main objective of this study was to determine how consumer knowledge (objective,
557 subjective and usage experience) affects consumer choices of food labeled for environmental
558 sustainability. We conducted similar choice experiments for both ground beef and potatoes in
559 Canada and Germany. Using a latent class choice modeling approach, we identified four
560 consumer segments that are similar for two countries and two product categories, though with
561 differing levels of knowledge and choice behavior. The covariate model in the latent class choice
562 model suggests that inclusion of subjective and objective knowledge regarding environmental
563 attributes, as well as usage experience, can significantly improve the identification of choice
564 patterns of the identified consumer segments.
565 *Hypothesis one* is only partially supported by our findings, in that respondents who
566 scored high on the objective knowledge index were not consistently more likely to make
567 environmentally friendly choices. However, those consumers who scored low were far less likely
568 to make environmentally sustainable choices. This is reflected in the choices by respondents in
569 the "*low knowledge"* class, who appeared to derive utility from high water usage and high
570 carbon emissions. While subjective and objective knowledge about environmental issues often
571 diverged as predicted, subjective knowledge was found to be more important for
572 environmentally friendly choice behavior, supporting our *hypothesis two*, which is in line with
573 previous work (Aertsens, et al., 2011; Ellen, 1994). In the "*low knowledge"* segments, a positive
574 coefficient for the subjective knowledge index could frequently be found, suggesting that both

575 types of knowledge need to be positively aligned to foster environmentally sustainable choices.
576 At the same time, while "*price sensitive"* consumers scored high on objective knowledge, they
577 scored low on subjective knowledge, which is consistent with *hypothesis two*.

578 Respondents characterized by low usage experience (who indicated not to have
579 purchased environmentally friendly products in the last four weeks) were more likely to be
580 guided by low prices. However, reporting having bought environmentally friendly products did
581 not necessarily increase the likelihood of choice of low footprint alternatives. Similarly, being a
582 member of an environmental group did not contribute to explaining group membership or choice
583 patterns. These two findings suggest rejection of *hypothesis three,* which stated that high usage
584 experience (measured both in terms of previous eco-purchases and membership in environmental
585 groups) would characterize choices of lower footprint alternatives. To the contrary, we found
586 that for the German sample, members of the "*low knowledge"* class were more likely to be a
587 member of an environmental group, suggesting that such self-reported measures may not be
588 sufficient to explain environmental behavior. It could be that membership in an environmental
589 group was interpreted more broadly or that these participants simply do not see their food
590 choices as an avenue for environmentally friendly behavior. Future research could investigate the
591 relationship between membership in environmental groups and this influence on food choices
592 more closely to better explain the behavioral discrepancy that we observe.

593 We did not find support for *hypothesis four,* that consumers with higher knowledge levels
594 balance extrinsic and intrinsic attributes. Quite the reverse, we found that for those segments that
595 score high on all three knowledge dimensions, the extrinsic attribute of price was ignored. This
596 finding suggests that there is highly price in-elastic demand by highly knowledgeable consumers,
597 which is also consistently found for organic food purchasing patterns (Aschemann-Witzel &

598 Zielke, 2015; Hempel & Hamm, 2016). Relative to the highly knowledgeable consumer segment,
599 the segment with an average level of knowledge showed a more balanced pattern of choices,
600 balancing both price and environmental attributes. Whether we did not specify a critical price
601 threshold that would lead to a tradeoff between price and footprint values for "*avid*
602 *environmentalist*" remains subject to future research.

603 Overall, while we observe a generally similar pattern of segments for the two product
604 categories and countries, some interesting differences can be observed. The Canadian sample, for
605 example, was somewhat more price sensitive than the German sample. This cross-cultural
606 feature is interesting in the context of another eco-label study, which found European consumers
607 to be more willing to pay price premiums for eco-labeled wood and paper products than North
608 American consumers (Aguilar & Cai, 2010). For potatoes, in particular, the German "*price*
609 *sensitive"* class was 20 % smaller than in the Canadian sample and the "*avid environmentalist*"
610 class was larger in the German sample for both product categories, suggesting a generally higher
611 ecological orientation in this sample.

612 Water usage was the more important environmental attribute for the "*avid*
613 *environmentalist*" segment for potato choices in both countries. For the German "*open to*
614 *environmentalist*" classes and the Canadian "*price sensitive*" classes, water was more important
615 for both product categories. Possibly participants were more sensitive to the higher numerical
616 values cited for water usage relative to carbon emissions and weighted these more in their
617 choices.

618 In terms of policy and marketing implications, our results suggest that both subjective
619 and objective knowledge need to be positively aligned for footprint labels to have the anticipated
620 effect of influencing choices. Increasing both subjective and objective knowledge levels – rather

621 than focusing on higher levels of usage experience per se – appears likely to increase the
622 effectiveness of using carbon footprint labels to enhance environmentally sustainable
623 consumption patterns.

624 In line with previous research from Germany, Spain, Sweden and Poland (Grunert, et al.,
625 2014), we find that price sensitive segments are slightly overrepresented by men, while segments
626 characterized by consumers for whom prices are not major drivers but who derive high utility
627 from the choice of low levels of carbon emitted and water usage (our "*avid environmentalist*")
628 were slightly dominated by women. The "*avid environmentalist*", who account for some 20 % of
629 the Canadian sample and about 30 % of the German sample, can clearly be identified by positive
630 coefficients for both knowledge indices (thus supporting *hypothesis one*) as well as by high
631 usage experience, based on claims to have recently shopped for environmentally friendly
632 products. These characteristics are also consistent with the previous finding that early adopters of
633 new labels are well informed and indicate intent to purchase a product carrying the new label
634 (Thøgersen, et al., 2010).

635 The class we called "*open to environmentalism*" has some similarities to the "*avid*
636 *environmentalist*" segment in terms of their responses to water and carbon levels, although they
637 are more responsive to lower prices than are "*avid environmentalist*". Also, the "*open to*
638 *environmentalism*" group tended to opt out of the choice when they encountered alternatives that
639 did not correspond to their preferences. However, the results from the covariate model indicate
640 that this "*open to environmentalism*" group generally does not feel highly knowledgeable about
641 environmental issues and does not buy this type of products. Nonetheless, members of this class
642 may be possible targets for footprint labelling, in that our analysis suggests that they have
643 understood the concept and are less price sensitive than the "*price sensitive*" class. Providing

644 information that increases these consumers' subjective knowledge may influence the choices
645 they are making. A useful future research avenue could be to investigate the means to increase
646 consumers' subjective knowledge levels and determine the features that led them to opt out of
647 many of the choices presented to them. Addressing these issues by future research on
648 environmental sustainability labeling might aid in determining whether providing more
649 information about environmental labelling, and different label designs, might encourage
650 environmentally friendly choices. Clarification of why some participants chose to opt out would
651 aid in understanding motivations for stated choices to prevent information-overload and
652 confusion. Future research could prompt participants with an open-ended question of why they
653 chose the no choice option every time they do. These insights could then be used to interpret
654 results and design future studies more appropriately.

655 It could also be worthwhile to assess consumers' reactions to the display of one critical
656 footprint value only (e.g., only the value for water if this is the more critical attribute).
657 Determination of specific critical thresholds could therefore be another avenue for future
658 research.

659

660 **Conclusions**

661 This study set out to explore to what extent consumer knowledge affects environmentally
662 sustainable behavior. It identifies distinct benefits from target marketing of footprint-labelled
663 food products focusing on knowledge and lifestyle factors. Focusing on the role of consumers'
664 subjective and objective knowledge and usage experience, and contrasting large samples of
665 consumers from Canada and Germany, we show that including psychometric and demographic
666 variables in latent class choice models allows for a novel and meaningful differentiation between

667 consumer segments in the context of environmentally sustainable choices. Our results also
668 indicate a general preference among many consumers towards products labeled with carbon and
669 water footprints. Contrary to nutrition labelling (see Grunert, et al., 2010), where it is found that
670 understanding of label information is high but motivation or expected utility from purchasing the
671 healthier option is low, our results suggest that knowledge of environmental issues is low,
672 indicating an issue of importance for public policy.

673 We find that environmentally friendly choices are observed mostly for segments with
674 high objective and subjective knowledge. For segments with only high objective knowledge, we
675 find that price is the most important attribute. These segments show a preference for
676 environmentally friendly alternatives, but only if prices are low. For those classes with high
677 objective and subjective knowledge, we find that price plays only a minor role. Usage experience
678 – measured both in terms of previous eco-purchases and membership in environmental groups –
679 as third dimension of consumer knowledge, was found to be less important in influencing
680 environmentally sustainable food choices. The relatively large shares of segments characterized
681 by low objective knowledge indicate that educating consumers in terms of environmentally
682 friendly behaviors is still an important task for those who want to encourage environmentally
683 sustainable choice behavior. In terms of education, it is likely important not only to improve
684 objective but also subjective knowledge. Keeping in mind that subjective knowledge was
685 observed to be a stronger driver for environmentally friendly choices, it appears relevant not only
686 to provide information for the target consumers, but also to raise general awareness to make
687 shoppers feel that they are informed and equipped to make a better choice for the environment.
688 Roughly one fifth of the respondents can be termed "*avid environmentalist*," who can be
689 expected to be appreciative of a label which could guide their choices toward sustainability.

690 Our findings suggest specific avenues of action for marketers to improve consumer
691 targeting with a focus on consumer knowledge and awareness of environmental issues. In sum,
692 our comparative analysis of consumer samples from both North America and Europe suggests
693 that footprint information may be a useful tool for food marketers to help consumers make
694 environmentally sustainable choices, especially in countries where the general level of awareness
695 and knowledge of environmental issues is already high. It is, however, crucial to use a targeted
696 campaign that addresses both objective and subjective knowledge.
697

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887

888

Imagine you are in your usual grocery store and you would like to purchase 1 kg of ground beef you usually buy: Do you choose Alternative A, Alternative B or Alternative C?

1 kg of ground beef	**Alternative A**	**Alternative B**	**Alternative C**
Carbon (CO_2) emission equivalents	22.93 kg	26.37 kg	None of these
Water usage	13175.00 l	13175.00 l	
Price	6.75 CAD $	9.14 CAD $	
I would choose:			

Highlights

- Test role of subjective and objective knowledge, usage experience on choice making
- Analysis of psychometrics, demographics, preferences for environmental footprinting
- Latent class choice modelling carried out for data from Canada and Germany
- Choices made for ground beef and potatoes labeled for carbon emission and water usage