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Is food labelling effective in reducing climate impact by encouraging the substitution of protein sources?

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ABSTRACT

This study investigates consumer willingness to substitute high-emissions meat products with lower-emissions protein products, including blends of meat and vegetables. Survey data, including a choice experiment, are combined with data on the respondents' actual purchase behaviour. The traffic light carbon label has an effect on choice behaviour, as it increases the willingness to purchase lower-emissions protein products such as chicken and meat substitutes. We further find that the willingness to purchase these lower-emissions products is largest among individuals who are already purchasing most sustainably. We discuss policy implications from the expected impacts of carbon labels, and how such labels affect different types of consumers.

1. Introduction

The food sector produces approximately 25–30 percent of global greenhouse gas (GHG) emissions (Mbow and Rosenzweig, 2019), and the production of red meat causes high levels of GHG compared to other sources of protein (Poore and Nemecek, 2018). Therefore, changes in current protein consumption patterns are important in order to reduce its climate impact (Godfray et al., 2018; Willet, 2019). Reducing red meat consumption can be achieved in different ways, with varying levels of difficulty and commitment for the individual, ranging from reducing the amount of meat in a meal to going meat-free for some or all meals (Schösler et al., 2012). Various instruments are available to impact consumption patterns, including (i) provision of information, (ii) changes in the choice context, (iii) fiscal instruments such as taxes or subsidies, and (iv) regulating accessibility through prohibitions or requirements in the production stages (Godfray et al., 2018; Just and Byrne, 2019). One uncertainty with fiscal and accessibility regulations is whether policy makers are willing to take the required measures, such as imposing a tax that is sufficiently high in order to significantly change consumption patterns (Bonnet et al., 2020; Just and Byrne, 2019). Information provision does not directly interfere with individual choices or the circumstances for firms and may therefore be less exposed to political resistance, but the effect of providing information depends on reactions and preferences to such campaigns among consumers (Bonnet et al., 2020; Just and Byrne, 2019). Notably, climate information on food products, such as in the form of a carbon label, can assist consumers who wish to identify and make climate-friendly food choices.

Understanding the potential impact from providing carbon emission information is essential in order to successfully implement appropriate public or private information initiatives that aim to direct consumers towards more climate-friendly food choices. The main objective of this study is to explore the expected impact of a climate label on the choice of lower-emissions protein sources. We investigate which types of lower-emissions protein sources consumers are most likely to accept as substitutes for red meat. In doing so, we combine data from a survey and experiment with data on the same respondents' actual purchase behaviour.

A recent body of studies based on surveys and experiments has investigated the willingness of consumers to pay a premium for variants of a product that emit less carbon, all else equal (Akaichi et al., 2020; Canavari and Coderoni, 2020; Elofsson et al., 2016; Feucht and Zander, 2017; Grunert et al., 2015; Lombardi et al., 2017; Peschel et al., 2016; Thøgersen and Nielsen, 2016; Van Loo et al., 2014). Importantly, the existing literature has focused on exploring the willingness to pay for relatively small reductions in carbon emissions within product categories, but has not examined substitution patterns between high-emissions products and lower-emissions ones. A recent exception is

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Van Loo et al. (2020). Nevertheless, achieving significant carbon reductions in food consumption will require transitions between product groups (Godfray et al., 2018; Poore and Nemecek, 2018). Therefore, it is important to investigate the willingness to make such substitution patterns between higher- and lower-emissions protein products.

The implementation of labelling policies to reduce carbon emissions from red meat consumption requires a greater understanding of which types of low-emissions protein sources different consumer types are most likely to accept. To this end, we use data from a survey distributed to a consumer panel, which includes stated preference data obtained from a choice experiment. We then combine and match that data with individual-specific data about actual purchases, as registered through scanner data. The data on actual purchases per product category allow us to judge the overall effectiveness of the stated preferences for climate labels. This provides an important advantage compared to previous studies on consumer reactions to food-related climate labels. In essence, the impact of climate information on food products will be larger when there is greater interest in such information among those with a large potential for substitution to products with less climate impact; that is, among those who currently buy the most products with high climate impact.

2. Method

2.1. Background and research objective

Numerous labels are available on the market that inform about different aspects of sustainability, including organic, animal welfare, fair trade (Grunert et al., 2015; Yokessa and Marette, 2019). The impact of such labels that inform about the credence qualities of the product rely on at least part of the population preferring the aspects that the label informs about (Caswell and Anders, 2011). The objective of the present study is to explore whether a carbon emission label affects consumer choices of protein sources. To this end, we construct a choice experiment that enables us to test for effects from a carbon emission label and validate the results from the experiment with actual purchase behaviour. Hence, the analysis is based on two sources of data: (1) survey data, including stated preference data from a choice experiment, and (2) actual purchase data, as reported in scanner data.

2.2. Data sources and sample

Fig. 1 presents an overview of the data sources, and the structure of the design of the survey instrument, while more detailed descriptions of each element follow. As depicted in Fig. 1, a survey, including a choice experiment, was distributed to an online panel held by the retailer Coop, in November 2019, resulting in 1052 responses. Given that Coop is among the largest retailers in Sweden, we do not expect that their consumers are systematically different in any important way from the Swedish population. The composition of the sample, described by socio-demographic characteristics, are presented in Table A1 in the appendix. There is an overrepresentation of older and higher-educated individuals, so we use weights to correct for this in our estimations. The sample is overrepresented by females, which is typical for consumer panels, since females are more often responsible for household grocery shopping (Lusk and Brooks, 2011). Collection of the survey data was preceded by two focus group sessions, interviews with market specialists at a large grocery store, a small pilot study where comments were collected (N = 25), and analysis of sales data.

2.3. Discrete choice experiment

Several aspects were taken into consideration in the selection of product for the choice experiment. Minced meat was selected as it is a product type that enables a wider product definition to allow substitution between types of protein, while also being a familiar product that is purchased regularly by many consumers (Apostolidis and McLeay, 2016; Koistinen et al., 2013). The experiment should enable us to examine which types of lower-emissions protein sources different consumer segments are most likely to accept as substitutes for red meat. For this reason, plant-based meat substitutes are included in the choice tasks, as such products may provide a feasible option for reducing meat consumption. However, while demand for meat substitutes has increased in recent times, many consumers do not purchase such products because they are perceived as unfamiliar or expected to be of poorer taste or nutritional quality (Hartmann and Siegrist, 2017). For this reason, a middle-way alternative is proposed, and implemented on some markets, where plant-based ingredients are blended with meat (Lang, 2020). This

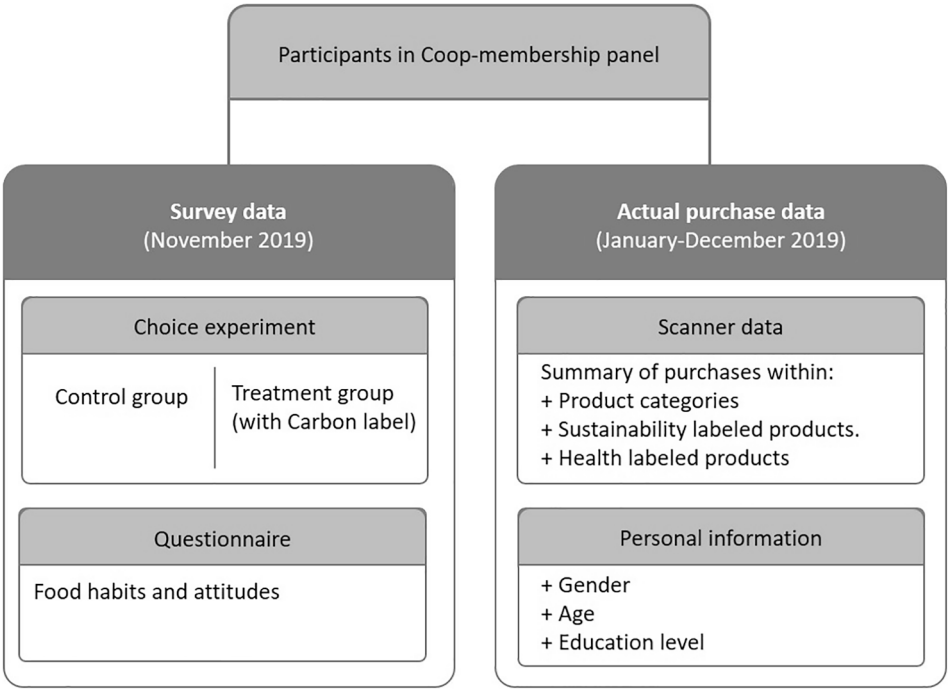

Fig. 1. Overview of data sources and study design.

is sometimes referred to as 'hybrid' meat products (de Boer et al., 2013; Neville et al., 2017). However, insights into which consumers find this to be a feasible alternative are relatively unexplored (Lang, 2020). Such a hybrid meat product is also included in the choice tasks.

The choice experiment includes six different product types: three different types of red meat (beef, beef & pork 70/30 mix, beef & pork 50/50 mix), a hybrid product (blend of red meat and vegetables), chicken, and a meat substitute. Products were described by production method (organic/conventional) and price (Table 1). To test for effects on choice behaviour from a carbon label, the survey was split into a control group and a treatment group, where a carbon label was displayed in the treatment group only. A carbon label should provide consumers with information about the climate impact of products and enable them to identify low-carbon alternatives. However, the effects of a label rely on consumers' willingness to incorporate the information into their purchase decisions. The carbon label was in the form of a traffic light system, where the colour requirements (CO_2-equivalent thresholds for green and yellow) were developed by Röös et al. (2014) (left panel in Fig. 2). We acknowledge that there are variations in carbon-emission equivalents within meat types (such as lower and higher emissions from the production of 1 kg beef), but beef with the lowest emissions is still much higher than the highest emissions from chicken or vegetarian protein sources (Poore and Nemecek, 2018). We note that with this type of traffic light carbon label, there is no new information for consumers who are knowledgeable about the climate impact from different protein sources. For these individuals, the climate label will serve as a reminder and make the information more salient in the purchase situation. However, for many individuals, prior knowledge or experience is relatively sparse and the label will make carbon emission information more accessible.

Individuals in the treatment group were presented with products with carbon labels. Prior to undertaking the choice tasks, they were provided a brief explanation to the carbon label, as described in Fig. 2.

The choice experiment design was generated using a d-efficiency criterion for a main effects MNL model, with priors from the pre-analysis. Respondents were presented with six choice tasks, each including six alternatives and the option to refrain from purchasing any product (*opt-out*). The visual presentation of the choice tasks was similar to the retail outlet's online-shopping tool, to provide as high ecological validity as possible. For example, while the size (in grams) and country of origin did not vary, this information was included to increase realism. All products were indicated to be domestically produced, based on the dominance of such minced meat products in the sales data. Moreover, focus groups suggested that the country of origin was a decisive attribute for many participants, so we decided against including it in the experiment to retain focus on the research questions. An example of a choice task is displayed in the right panel of Fig. 2.

The stated preference data from the choice experiment are analysed by estimating discrete choice models. Taking departure in random utility theory, we assume that individuals are utility-maximising and that the products can be described and valued by their attributes (McFadden, 1974; Train, 2009). We estimate mixed logit (ML) models, where the choice probability is estimated, while incorporating heterogeneity between individuals. Based on each individual's observed sequence of choices, it is possible to obtain individual-level preference parameters. The estimated distribution of the preference parameters are used for this purpose, and we thus obtain estimates specific for each individual.[1] More details on the discrete choice models are available in Section A1 in the Appendix. Models are estimated using the Apollo package in R (Hess and Palma, 2019), and *mixlogitwtp* in STATA (Hole, 2015).

Table 1
Alternatives and attribute levels in choice experiment.

Option	Carbon label[a]	Organic	Price (SEK)[b]
Beef	Red	1/0	32,42,52,62,72,82
Beef and pork (70/30)	Red	1/0	28,36,44,52,60,68
Beef and pork (50/50)	Red	1/0	28,36,44,52,60,68
Beef and vegetables (50/50)	Yellow	1/0	28,36,44,52,60,68
Chicken	Green	1/0	28,36,44,52,60,68
Vegetarian	Green	1/0	28,36,44,52,60,68

[a] Red indicates more than 14 kg CO_2equivalents per kg of product; yellow indicates 4–14 kg CO_2e; and green indicates less than 4 kg CO_2e.
[b] At the time the study was conducted, 10 SEK ~ €0.95.

2.4. Actual purchases by the respondents

In addition to the survey data, we obtained summary statistics for the individuals' purchases from all of the retailer's stores in the year the survey data were collected (2019) (see right panel in Fig. 1). These actual purchase data serve to validate the results from the stated preference data.

In the survey, respondents indicated whether they have any restraints in their diets, and 6 percent stated that they follow a vegetarian or vegan diet, while 10.6 percent exclude red meat but eat fish and eggs. A further 3.8 percent do not eat pork, and 10.0 percent follow a diet to lose or maintain weight. We note that 87 percent of the respondents who claimed to avoid red meat had purchased such products during 2019, which may be due to purchases for other members of the family.

Twenty-four respondents in the survey did not purchase any products from any of Coop's stores in 2019. Moreover, the total amount spent over the year by some of the respondents was small, which implies that they used Coop's stores for sporadic purchases, so their data is probably not a good representation of their total food purchase patterns. For this reason, we present summary statistics for individuals who spent at least 5000 SEK (~€470) (Table 2). Excluding the sporadic consumers, our sample retained a total of 766 respondents. We tested different limits in the range of 1000–10,000 SEK and found that moving the limit from 5000 to 10,000 has little impact on the variables. Statistics for the full sample are presented in Table A2.

The proportion of specific food categories is obtained from the total purchases of food products (that is, excluding other products sold by the retailer, such as household items, beauty products, gardening materials, and tobacco). Similarly, the proportion of health-classified products is obtained as a fraction of the total food purchases. The health category includes products that were labelled with the national Nordic Keyhole health label (Livsmedelsverket, 2020). This is a voluntary label, administered by the Swedish Food Agency, that indicates healthy alternatives within product categories. For the products with a sustainability label, the number is obtained from total purchases, including certain non-food items such as household and personal care products, since these non-food products can be sustainability-labelled (environmental labels on paper towels, soap, etc.). The sustainability category includes products that are labelled with at least one of a set of sustainability labels (Organic (national or EU label), MCS, ASC, Nordic Swan, FSC, UTZ, Rainforest Alliance). The healthiness variables also include products that are low-fat or low-sugar. While these purchase variables are rough measures, they provide indications of actual purchase patterns.

3. Results

3.1. Impact from climate label on preferences towards protein sources with lower-carbon emissions

We test whether the inclusion of climate labels affects the probability of choosing product types that are lower in carbon emissions. Interaction variables are included between product characteristics and the presence of a carbon label (treatment group) in an ML model on the choice

[1] While these posterior parameters are referred to as individual-level, they are parameters for the subpopulation of individuals who made a certain sequence of choices. For more details, see Section A1.

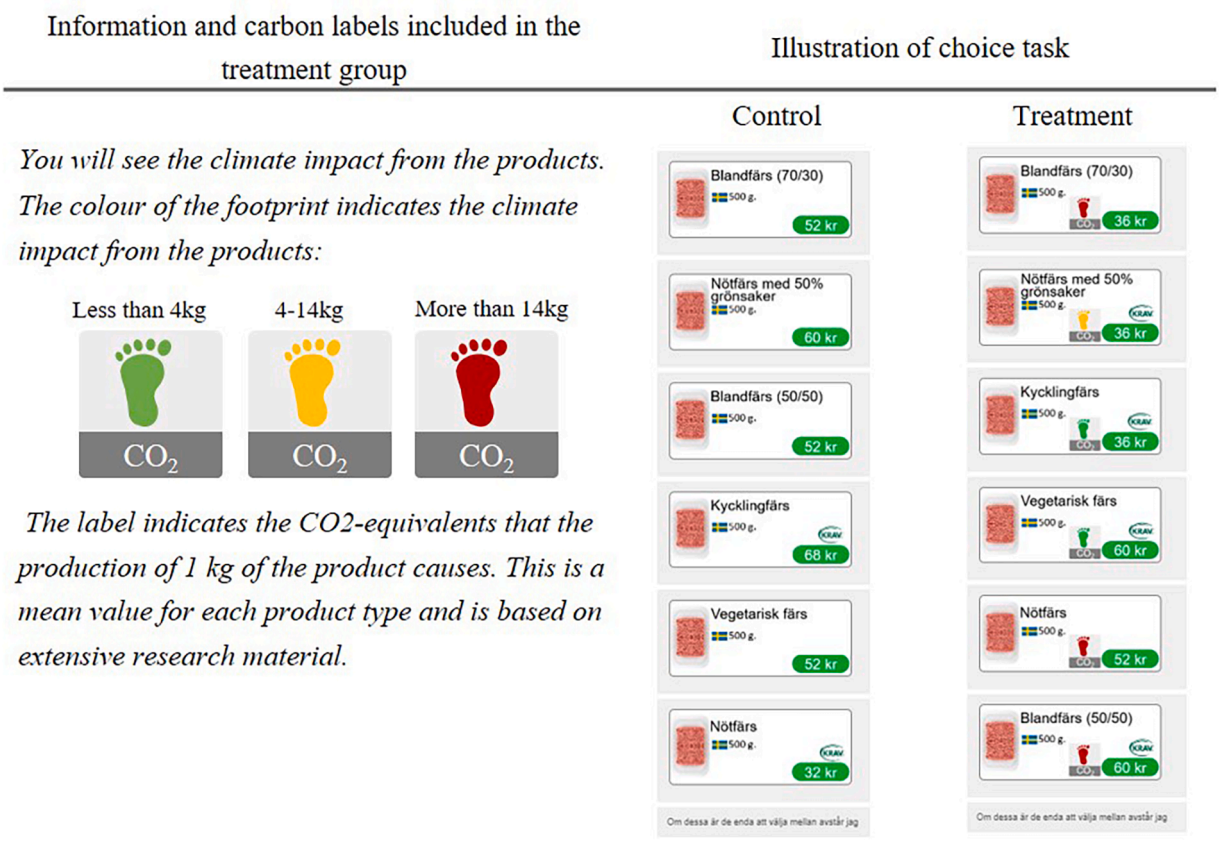

Fig. 2. Carbon labels and example of choice tasks in control and treatment group.

Table 2
Percentage of total annual actual spending per product category (2019).

	Median	Mean	Std. Dev.	Min.	Max.
Product categories					
Fruit and vegetables	16.4	17.1	6.3	0.8	39.8
Meat and meat products	12.7	13.0	6.7	0.0	45.6
Fish and seafood	5.1	6.0	4.8	0.0	42.6
Dairy	15.4	15.7	5.4	0.5	41.8
Poultry	1.4	1.9	2.0	0.0	14.5
Product labels					
Sustainability-labelled	13.9	17.8	13.2	2.3	93.6
Healthy alternative	20.8	21.6	7.8	1.7	49.4
N	766				

Note: Comprising individuals who spent greater than 5,000 SEK (n = 776).

experiment data (Table 3). All attribute parameters are specified with normal distributions, while the price parameter takes a negative lognormal distribution, given that price is assumed to be negative for all individuals. The mean parameters are interacted with the treatment (carbon label) to test whether the preferences are different, on average.[2] We control for scale differences between the control and treatment groups. All mean parameters are statistically significantly different from zero. Beef & pork 50/50 is the base level, so estimates for the other meat types give the preference compared to this product type. Beef is the most preferred product type, followed by mixes of beef and pork, while chicken is the least preferred type. The positive parameter for organic is in line with previous literature and market data; on average, consumers prefer organic products over their conventional counterparts, all else equal. The standard deviation parameters for product types and organic are all different from zero, and the relative size of the mean compared to the standard deviation reveals a large preference heterogeneity for all product types. The negative *opt-out* parameter implies that, on average, individuals prefer to purchase a product.

The impact of the climate label is revealed in the interaction terms (*Carbon label-interactions* in Table 3). The positive and statistically significant interaction parameters for chicken and meat substitutes respectively imply that, on average, preferences towards these products are less negative when a carbon label is included. The preferences for products where beef is blended with vegetables are no different, on average, when a climate label is included. The insignificant interaction terms between carbon label and beef and beef & pork (70/30) are to be expected, since these product variants are not labelled differently from the reference product (beef & pork 50/50). The interaction between the presentation of the carbon label and the product being organic is negative and statistically significant, which suggests that there is decreasing marginal utility from additional sustainability labels.

3.2. Purchase behaviour in choice experiment and actual purchase behaviour

Next, we test how the willingness to purchase low-carbon substitutes for minced red meat relates to actual purchase patterns. We estimate ML models on the choice experiment data for the control and treatment samples, respectively. The preference parameters in discrete choice models cannot be compared between models. However, ratios between two estimates, such as the attribute-price ratio (willingness to pay), can be compared across models. We obtain the WTP-estimates directly by

[2] We do not include an interaction variable between carbon label and price. Following our hypothesis, we do not expect the price parameter to vary between the treatment groups, and this was confirmed by LR tests.

Table 3
Results from Mixed Logit model on choice experiment data including effects from carbon label.

	Mean	Std. Dev.	Carbon label-interactions
Attributes:			
Beef	0.694**	2.504***	−0.482
	(0.240)	(0.243)	(0.317)
Beef & pork 70/30	−0.827***	1.078***	0.083
	(0.157)	(0.132)	(0.174)
Beef & pork 50/50	0		
Beef & vegetables	−1.865***	3.036***	0.360
	(0.387)	(0.325)	(0.443)
Chicken	−9.027***	6.485***	2.673*
	(1.949)	(1.393)	(1.353)
Meat substitute	−2.119***	2.852***	1.679**
	(0.457)	(0.373)	(0.530)
Organic	0.707***	0.734***	−0.438**
	(0.119)	(0.113)	(0.142)
Price [a]	−3.960***	1.090	
	(0.582)	(0.816)	
Alternative specific constant:			
Opt-out	−5.344***	5.398***	−0.106
	(0.937)	(0.744)	(1.413)
Scale-parameter:[b]	0.162		
	(0.158)		
Obs. / Individuals	6312	/ 1052	
LL	−8254		
Adj. rho2	0.326		

Note: Robust standard errors are in parentheses and * indicate if $p < 0.05$, ** if $p < 0.01$, and *** if $p < 0.001$ [a] Price takes a negative lognormal distribution. The estimated parameter is $\log(\beta_{price})$. The $median_{price} = -\exp(\beta_{price}) = -0.019$, $mean_{price} = \exp(\beta_{price}+(s^2_{price}/2)) = -0.025$ and $Std.Dev_{price} = mean_{price}*(\exp(s^2_{price})-1)1/2 = 0{,}021$. [b] Scale parameter (λ) for treatment group relative to control group. It is specified in exponential form and should therefore be compared against zero.

estimating the models in WTP space.[3] From these models, we obtain individual-level WTP parameters based on the choice sequences made by each individual.

To further examine how the WTP for specific product types relate to the individuals actual purchase behaviour, we regress the individual-level WTP estimates on the actual purchase patterns by the individual, while controlling for treatment effects (Table 4). Our main interest is in exploring the actual purchase patterns among individuals who are willing to purchase lower-emissions protein products. The results shows that individuals with a high share of actual meat purchases have a statistically significantly lower WTP for chicken and meat substitutes over beef & pork 50/50. However, the WTP for the lower-emissions meat blend product (beef & vegetables) is not associated with specific purchase patterns on the measured products, which suggests that this type of product is not more feasible for heavy meat consumers than it is for those who purchase lower amounts.

4. Discussion

Changes in current consumption patterns are vital in order to lower climate emissions; a reduction in red meat consumption is an important aspect of this (Godfray et al., 2018; Willet, 2019). Affecting consumption patterns through initiatives to provide information is one of several instruments that can be used. However, the outcome from implementing, such as carbon label on food products, depends on the consumers' willingness to change their purchase behaviour (Bonnet et al., 2020; Just and Byrne, 2019). Given the importance of reducing meat consumption, we explore the expected impact of a climate label when choices are made between meat products and lower emissions substitutes. An important strength of the analysis is that we combine survey and experimental data with actual purchase data and match this at the level of each individual respondent, which allows us to validate the stated attitudes and preferences with revealed behaviour.

Reducing the climate impact of meat consumption can be demanding for individuals, as it requires some degree of change in habits and tradition and may require the attainment of new cooking skills. Replacing meat with meat substitutes is one measure that can be taken to reduce meat consumption, and such products have gained increasing market presence, although the market share remains small (Apostolidis and McLeay, 2016). We find that, on average, individuals prefer meat products to meat substitutes, although acceptance of the latter increases when carbon labels are displayed on the products. Therefore, our analysis indicates that carbon emission labelling is expected to have some impact in the direction of more climate friendly product choices. It should be noted that the carbon emission label in this study, in the form of traffic-light-coloured footprints, was briefly explained to the participants in the experiment. Hence, the effects that we find from the label is based on the premise that the consumers are informed about the meaning of the label, and their attention is focused toward the label.

It has been proposed that new product variants, where minced meat is blended with vegetables, make it less demanding for meat-eating consumers to reduce red meat consumption (de Boer et al., 2013). Lang (2020) found that health aspects are important motivators for purchasing such blended products and, to a lesser degree, environmental concerns. However, contrary to meat substitutes, the probability of choosing a blended product was unaffected by the inclusion of carbon labels. Moreover, the probability of considering and choosing a blended product does not vary with current purchase patterns; that is, we cannot say which consumer profile a blended product is most appealing to.

4.1. Limitations and future research questions

A person's motivation for reducing meat consumption may vary, including with regard to environmental, health and animal-welfare arguments, and while this study focuses on the climate aspect, future studies should include other aspects for a broader understanding of the behavioural changes that different labelling regimes can achieve. Another area of interest for future studies lies in the expected impact of climate information being provided on different product categories. This study is limited to the choice behaviour regarding one product (minced meat). Future studies may explore whether carbon labels have a larger impact on, for example, ready meals, for which new cooking skills are not necessary. While the effects of the label are limited in this study, we recognise that the long-term effects are not analysed. Recognition and learning may lead to larger effects in the longer term (Thøgersen, 2002). However, it is also possible that the introduction of a label will imply larger competition with other labels and, hence, cause smaller effects than in this study. These questions call for further studies.

4.2. Conclusions and policy implications

Will carbon labels on food product contribute to lower climate impact? Importantly, the contribution of this study is to combine and match survey and experimental data with data on the respondents' actual purchase behaviour. Previous studies that have investigated the effects of climate labels on consumer preferences have focused on substitutions *within* product categories. However, larger reductions in climate impact require substitutions *between* high and low-emissions product categories, where meat is an important product. This has important implications for the delivery of carbon labels as a measure for reducing the climate impact of food production. A carbon labelling regime needs to be present across narrowly defined product groups if it

[3] WTP space implies a re-parameterisation of the ML model, where the WTP, which is the ratio between attributes and the price estimate, is estimated directly in the model (Train and Weeks, 2005). The utility function is presented in Section A1.

Table 4
Linear regression of actual purchases and treatment on individual-level WTP estimates.

Variable:	WTP beef		WTP Beef & pork 70/30		WTP beef &veg.		WTP chicken		WTP meat substitute		WTP organic	
Treatment (carbon label)-dummy	−21.17	***	2.80	*	−3.59		52.22	***	31.88	***	−16.13	***
	(5.23)		(1.20)		(5.37)		(9.24)		(5.73)		(1.13)	
Share actual purchases: [a]												
Fruit & veg.	−17.69		−5.85		−42.46		−51.01		−105.26		23.37	
	(73.14)		(15.97)		(81.90)		(126.82)		(87.72)		(13.77)	
Meat	114.25	*	2.75		−19.27		−221.89	*	−161.16	**	7.75	
	(45.49)		(9.42)		(40.77)		(90.04)		(51.11)		(9.72)	
Fish & seafood	14.91		23.56		−8.73		38.16		−93.79		12.59	
	(52.62)		(12.69)		(52.93)		(103.25)		(55.09)		(10.88)	
Dairy	123.27	*	−2.86		46.48		18.62		−80.41		−0.16	
	(48.20)		(9.76)		(45.61)		(87.26)		(58.56)		(10.07)	
Poultry	152.13		−32.94		142.54		−188.16		750.33	***	98.49	***
	(134.78)		(26.74)		(159.38)		(241.15)		(174.81)		(28.29)	
Sustainable	−5.03		−6.61		7.95		104.61	*	24.73		24.27	***
	(21.18)		(5.11)		(21.72)		(52.63)		(26.24)		(5.49)	
Healthy	−40.10		1.79		84.67		40.96		186.21	*	−22.67	
	(61.74)		(13.87)		(67.42)		(119.81)		(72.51)		(12.16)	
Constant	5.17		−25.86	***	−74.28	***	−283.09	***	−76.13	***	17.77	***
	(14.81)		(3.18)		(14.77)		(31.53)		(18.07)		(3.69)	
R^2	0.05		0.02		0.01		0.07		0.12		0.27	
P-value (all coefficients)[b]	0.000		0.101		0.373		0.000		0.000		0.000	

Note: Dependent variable is individual-level WTP-parameter is obtained from ML model. Beef & pork 50/50 is base level. WTP in SEK. 10 SEK ~ €0.95. N = 766 for all models. Robust standard errors are in parentheses and * indicates if $p < 0.05$, ** if $p < 0.01$, and *** if $p < 0.001$ [a]Share actual purchases are measured as the share of total food purchases. [b] P-value refers to F-test of the null hypothesis that all coefficients are equal to zero.

is to help consumers identify substitutions that cause significant reductions in carbon emissions. This poses a challenge should the label be voluntary, as producers of high-emissions products are less likely to include such information.

Overall, our findings highlight that a carbon label that informs about differences in carbon emissions *between* rather than *within* product categories affects consumer choices towards lower emitting variants. We find that the willingness to pay for lower emitting protein products is largest among individuals who currently purchase the least amount of meat and the highest amount of sustainable products. While this finding is not surprising, it does highlight the limitation with labelling as a policy instrument for achieving significant behavioural change. Therefore, the major policy challenge is how information can be used to attract and engage consumers who have the potential to contribute most to a reduction in meat consumption. We note that similar challenges exist for health-related information. Edenbrandt and Smed (2018) found that the healthiest consumers purchased products labelled as healthy to the largest degree. Similarly, (Fang et al., 2019) found that the revised nutrition facts labels mandated by FDA mainly affect individuals who already use health labels.

Lastly, it is worth noting that while carbon labels may have a limited impact on consumer choices in themselves, they may play a role in combination with other measures (Bonnet et al., 2020). Requirements for including nutrition and health information on products have caused producers to reformulate their products, and similar developments may result from the introduction of comprehensive carbon-labelling programs. Moreover, retailers can contribute by facilitating product comparison for consumers; for example, by placing lower-emissions protein sources in the same choice set (such as a store shelf) as higher-emissions red meat variants. A higher presence and visibility of lower-emissions protein sources in the purchase situation may induce social learning (Edenbrandt et al., 2020) and have an impact on social norms that enhance substitutions (Bonnet et al., 2020).

CRediT authorship contribution statement

Anna Kristina Edenbrandt: Conceptualization, Formal analysis, Methodology, Investigation, Writing - original draft, Funding acquisition. **Carl-Johan Lagerkvist:** Conceptualization, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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