Motivated Beliefs: Evidence from an experiment on climate-smart dairy in the UK

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Abstract
The UK dairy sector strives for net-zero by 2050. This implies the adoption of climate-smart technologies, which improve efficiency, reduce emissions, and build carbon storage. We assess how consumers perceive these technologies, i.e. their knowledge and preferences, and how much they are willing-to-pay for milk produced using smart-dairy technologies. We distinguish between three different avenues: a nature-based approach which increases carbon sequestration, a technology-based approach which improves system efficiency, and an emission-reduction-based approach which tackles emissions directly at the source. We set up a laboratory experiment with three information treatments – labels, posters, and videos. We collect data on knowledge, stated preferences and willingness-to-pay before and after the information interventions. Results suggest a lack of effects of the video and poster interventions (as opposed to the generic label) to increase willingness-to-pay, although significant effects are found on knowledge and stated preferences. The participants slightly prefer nature-based approaches, and videos increase these preferences. Both posters and videos also increase stated preferences for the nature-based and emission-reduction-based approaches. These results support theories of motivated and anchored beliefs: when receiving more information, biases are confirmed towards nature-based approaches; and preferences and knowledge respond together when learning about the more unknown emission-reduction approaches.

Keywords: Dairy farming, Climate Change, UK, Consumer Preferences

JEL Classification: Q1, D8

1 Introduction

The impact of the agricultural sector on climate change is increasingly evident and difficult to overlook, especially in the UK where agriculture contributes 44 million tons of CO_2 equivalent emissions annually. The dairy industry, responsible for 2 to 3% of these national greenhouse gas emissions, largely emanates from farm-level activities (Brown et al., 2023).[1] Amidst growing public concern, evidenced by a YouGov survey indicating 76% of UK consumers worry about climate change and 33% view dairy farming as a significant contributor, there is an urgent need to transform production methods to meet climate-neutral goals (**?**).

This transformation, essential for achieving the UK's net-zero target by 2050, requires a shift in dairy farming practices and possibly entire systems, in a context of limited direct government support. The UK's Agricultural Transition Plan emphasizes technological innovation and long-term environmental investments over direct income support, placing the financial burden of eco-friendly innovations on consumers through higher prices. This market-focus puts the consumer front and central: the consumer is expected to pick up the tab of any cost-increasing innovation, in the form of increased prices.

The extent to which consumers are willing to pick up this price increase is debatable. Li et al. (2016) find that the main determinant of the consumer's willingness-to-pay for climate-friendly beef production methods is income. The current cost of living crisis might imply that consumers might not care much about how a product was made. Yet, consumer preferences are rapidly evolving, increasingly favoring products that are sustainable. While consumers might be increasingly switching to plant-based diets, sustainability credentials of animal-based products appear important as well. Canavari and Coderoni (2020) offer a review and find evidence of this widespread shift. For example, there is a 22% higher willingness-to-pay for rice in the USA when consumers are assured the product is of local origin or low carbon footprint and a 29% higher willingness-to-pay for milk in Chile.

[1] Major sources within dairy systems include methane from enteric fermentation (58%), CO2 and nitrous oxide from feed production (29.4%), and emissions from manure management (, n.d.).

In the case of dairy, animal welfare might complicate matters. Koistinen et al. (2013) find that independent of organic production, the welfare of animals matters to consumers. But not all consumers value these attributes equally. Grebitus, Steiner and Veeman (2013) note that consumers who hold stronger intrapersonal values (relative to interpersonal values) are less likely to act in environmentally friendly ways. This implies that dairy consumers might not only care about the bottom-line climate impact of a product, but also as to how this impact is achieved, meaning the details of the production methods.

Our overall goal is to obtain a clearer understanding of the acceptability of climate-smart innovations that can be implemented in the dairy sector in the UK.

We conducted a consumer experiment is to assess the consumers' willingness to pay for climate smart dairy technologies. We presented three different avenues to improving the climate credentials of milk, nature-based route which increases carbon sequestration, a technology-based route which improves system efficiency, and an emission-reduction-based route which tackles emissions directly at the source. We then tested as to whether the willingness-to-pay for climate smart milk can altered, and assess the role of three different styles of information provision: a traditional label, a standard poster, or short videos. In context, we allow for "irrational" consumers, who change their willingness-to-pay not just as a response to additional information, but also information which is presented in a more attractive manner. We allow for consumers to revisit their knowledge of the sector, but also their preferences and values, creating a joint response of knowledge, preferences, and willingness-to-pay.

The experiment was conducted with about 568 staff and students at a university in the UK. The research participants were presented with a series of questions, eliciting their knowledge, stated preferences and willingness-to-pay for the climate-smart innovations bundles. The research participants were randomly assigned to three information treatments, and these elements were elicited both before and after the intervention took place.

The first treatment group watched videos of the three innovation bundles. The second treatment group received a poster with similar information content. The last treatment group received a picture of a label, only noting the overall emission-reduction level. These labels were also viewed by the poster and video group participants. These visual materials were created on the farm of five selected dairy farmers.

This design was motivated by both policy considerations and grounded in the literature. We anticipated that elements of the choice architecture would have important effects. For example, Tobler, Visschers and Siegrist (2012) note that perceived and not actual climate costs and benefits are most predictive for willingness to act regarding climate policies. This suggests that consumers need to trust the information provided to them, whether in the way of labels, or another format. Kimura et al. (2010) note that more accessible information (i.e. written on the label more clearly) around climate impacts of a product will lead to more climate friendly consumer choices. This implies that we can expect these differential forms of information provision to possibly have different effects on willingness-to-pay, possibly by changing beliefs as well as preferences.

On the policy front, we selected three realistic alternative information approaches. The first one is a label, and as the label was used also in the other two treatment groups, this should be viewed as the benchmark. Labels are commonly used by dairy brands, for example, Yeo valley, to convey attributes not just of the dairy product, but also of the production process. To avoid issues of plagiarism, we designed our own label, which we then pre-tested among consumers. The second approach is a poster. We envision this to be a realistic approach among supermarkets, who can advertise the attributes of a new product in an isle on eye-height (albeit perhaps not as detailed as we did). The last approach is a video, and we envision a TV campaign by a dairy supply board, such as the Royal Association of British Dairy Farmers.

In addition, we hypothesized that it would not just be the ‘climate-smartness’ which matters, i.e., the reduction in carbon footprint, but also how this reduction was obtained. The consumers’ response can vary, and not just based on the characteristics of the consumer, but also based on the nature on the innovation. Innovations that impact on the physical qualities of the product tend to be much more readily perceived than innovations in the process of food production (Grunert, 2005). Innovations that alter the perceived ‘authenticity’ of food products are more likely to be viewed unfavourably than innovations that are neutral or enhancing on this dimension (Almli et al., 2011). Most studies of consumer response to innovation in food products have focused on those that alter intrinsic qualities, such as packaging, labelling and formulation, while relatively few have concerned production process innovation and fewer still have had a focus on process innovations that yield environmental sustainability benefits (Naspetti et al., 2021). Nicholas et al. (2014) explores attitudes towards 34 different innovations in organic and low input supply chains, including dairy consumers, in four European countries, including UK. They find that innovations perceived as compromising naturalness, including genetic modification, were received negatively, while innovations that improved animal welfare, improve forage quality and reduce use of imported concentrate feeds, were positively received. Related to our UK focus on feed additives, this study found that feed additives which reduce greenhouse gas emissions without reducing milk yield or quality, are negatively perceived by the consumers in the various countries (there were only marginal differences between countries).

Our experiment is set up to address these exact gaps in the literature. Our study contrasts three forms of information provision and three routes towards climate-smart dairy practices, examining how these two aspects interact with each other. We assess the willingness to pay for climate-smart dairy milk both before and after the interventions, including within our control group. This approach enables us to isolate the effects of the information campaign and compare its impact across different bundles. This set-up allows us to get a better sense of which technologies consumers favour, and which they oppose, and, whether the willingness-to-pay is firmly rooted in the consumer preferences, or can it, by providing credible information, be altered?

We find that our participants indeed slightly prefer nature-based approaches, and that the provision of videos increase these preferences, as measured by willingness-to-pay. Both posters and videos (as opposed to the generic label) also increase stated preferences for the nature-based and emission-reduction-based approaches. Overall, however, our results suggest a lack of effects of the video and poster interventions (as opposed to the generic label) to increase willingness-to-pay, although significant effects are found on knowledge and stated preferences. These results support theories of motivated and anchored beliefs: when receiving more information, biases are confirmed towards nature-based approaches; and preferences and knowledge respond together when learning about the more unknown emission-reduction approaches.

The rest of this paper is structured as follows. Section (2) provides some additional background on the UK's dairy sector and the research activities which took place prior to the experiment within our project. Section (3) describes the experimental design and Section (4) outlines the regression method used. Section (5) presents the results and Section (6) concludes.

2 Background

2.1 The UK dairy production sector

The size of the UK dairy industry has been significantly reduced both in terms of the size of the national herd and the total number of producers in the past 3 decades. According to the UK government statistics, the total number of UK dairy cows reduced from 2.6 million in 1996 to 1.9 million in 2020, indicating a 28% reduction with an average herd size of 160 across 5,330 dairy holdings (Government, 2021). However, productivity of the average dairy herd has increased and thus is compensating the reduction in the number of animals and dairy holdings. The average yield per cow in 2022 was 8,166 litres per annum, an increase of 9.6% when compared to 2016 and 26% when compared to 2002 (DEFRA, 2023).

2.2 Innovations and climate smart management practices

UK farms are highly variable enterprises with differing sizes, housing systems, milk production levels, cow breeds and intrinsic spatial characteristics. Unsurprisingly, there is also variation in the type of innovations and climate smart management practices open and suitable to different dairy farms. Beyond the farm gate, the UK has a complex supply chain in comparison to many European counterparts.

Moreover, exploring the traits of high-performing dairy farms in England, Jones (2020) revealed that those with larger herd sizes tended to exhibit superior productivity. Conversely, smaller herd sizes were linked to lower farm productivity. Thus, a farm with a larger dairy herd, operating with equivalent costs and land as a smaller herd, demonstrated greater efficiency. There is therefore significant heterogeneity within the dairy farming community and amongst individual farmers in their ability to adopt new innovations and management practices to enhance the efficiency of the dairy production system.

The UK is aiming to achieve Net Zero agriculture, and the contribution of the dairy sector in the success of this effort has been highlighted as the most important. Dairy farmers are reviewing their management practices and explore the options of new innovation technologies to reduce energy, production and supply chain emissions. Improving technical efficiency and productivity will reduce production and supply chain emissions, while the use of improved animal husbandry practices and technologies will enable to deliver a balance between economic, environmental and social sustainability (Allen, 2023).

2.3 Defining the three climate-smart bundles

Our team carried out four participatory workshops in 2022 with different dairy sector stakeholders to identify known climate smart innovations used in the UK and their expected level of implementation and effectiveness. Participating stakeholders ranked innovations based on an index which combined perceived consumer appeal, cost and ease of implementation, and climate and economic impacts. The highest ranking innovations and management practices from each workshop were selected by our team and were arranged into three bundles according to their mitigation approaches and outcomes. These bundles were selected to facilitate communication with non-expert consumers. The first bundle centres around what we called the 'nature-based' approaches, like grassland management, inclusion of herbal leys, the use of hedges, and the reduction of artificial fertilisers. These are the innovations and management practices which aim to balance out greenhouse gas emissions by improving soil health and increase carbon sequestration. The second bundle was termed 'technology-based', and included heat recovery systems, precision livestock technologies, and genetic selection. These technologies reduce the farm's carbon footprint through increased input efficiency. The third bundle was termed 'emission-reduction-based' and consists of innovations that directly tackle methane or nitrous oxide production at the source of emissions (the former is one of the most potent of greenhouse gasses, and one of the main environmental concern within the dairy industry). These innovations include the use of feed additives to reduce enteric methane released when cows burp, methane capture, and the addition of additive to farm yard slurry to minimise nitrous oxide and/or methane emissions.

The choice of these bundles was influenced by a series of consumer workshops we conducted in 2022. During these workshops consumers were presented with an explanation of the high ranking innovations and management practices gathered during the stakeholder workshops. We elicited consumer perceptions, beliefs and sentiments towards the various climate-smart innovations which were listed in our producers workshops. This exercise allowed us to recognise that possible existence of different types of consumers, which some consider 'natural approaches' to be important, while others had more more of a cost and price focus. Table 1 categorises the technologies by bundle.

2.4 Creating the visual materials for the experiment

We created the visual materials we needed for the experiment manner during in-person visits to several model farmers. These model farmers were selected through our earlier workshop, as to represent the various technologies listed in Table 1. Our visiting team included a professional videographer, a videographer's assistant, a social scientist, and a animal scientists. Using the farmer interviews, photos, and short video-clips we created professional-looking posters and short videos (5 to 7 minutes long) of each technology bundle.

3 Experiment

3.1 Overview experimental

The experiment took place at the Behavioural and Experimental Laboratory at Sussex University. Participants were identified using this laboratory's existing database (which consists of students, and staff at the University), and the university's social media (to invite consumers local to the area who are not staff or students). The total sample consists of 558 consumers.[2]

The experiment was programmed in Qualtrics, a specialist survey software program, and took at most one hour to complete. The experiment ran from June 2023 till November 2023.

We piloted the experiment among 29 participants. The purpose of the pilot was to pre-test the Qualtrics questionnaire and ensure that it can effectively and efficiently collect the intended data. In addition, it was also meant to check whether the computers and the entire system at the lab are working well. Once these checks were satisfactory passed, we moved on with the data collection mid June 2023.

This sample was split in three groups, randomly. The first group watched videos of the three innovation bundles, and answer questions about these. We call this group the video treatment. The second group viewed posters with similar information content, and again answered questions about these. We call this group the poster group. The control group watched an unrelated video. We view this group as an active control group, and call it the label group, for reasons to be made clear below. Each group completed a short survey, and then answered a series of questions on their perception, preferences and willingness-to-pay (WTP) for dairy products resulting from farms representing the three different bundles.

[2]While we initially aimed for a sample of 1000, we later on, after a power computation, and a reassessment of the budget settled on a sample of 600. The pre-analysis plan which includes the power computation can be found on the project website available at OSF https://osf.io/2ygmz/!

Table 2 gives an overview of the sample. There are 181 consumers in the label group, 194 in the poster group and 183 in the video group. The slight imbalance is due to the complexity in anticipating who will show up combined with us having to pre-program the treatment on any given computer in the laboratory. We detail the three treatments below.

3.1.1 Video treatment

Participants were asked to view three videos on each of the three bundles of smart dairy technologies – nature based, technology based, and emission-reduction based. The order of these videos were randomized for each participant. After every video, participants were asked a few comprehension questions, and also to indicate how much they would be willing to pay (in addition to what they usually pay) for milk with various levels of carbon equivalent emission reduction levels produced by this bundle (the reduction levels are 15%, 30%, 50%, and 100% - carbon-neutral). So for every level or carbon reduction, they were asked about their increase in willingness to pay (WTP) for milk produced using technologies that are associated to these levels of carbon emission reduction. In compliance with confidentiality, we are not able to share the videos.

3.1.2 Poster treatment

Participants were asked to view three posters on each of the three bundles of smart dairy technologies – nature based, technology based, and emission-reduction based. The order of these posters were again are randomized for each participant. Notably – they view these posters for the same length of time as the corresponding video. After every poster, participants were asked a few comprehension questions, and also to indicate how much they would be willing to pay (in addition to what they usually pay) for milk with various levels of carbon equivalent emission reduction levels produced by this bundle (the reduction levels are 15%, 30%, 50%, and 100% - carbon-neutral).

The three posters are included in the appendix materials. See Figures 3, 1 and 2.

3.1.3 Active control: Label

Participants in this group were shown an unrelated video from the BBC (British Broadcasting Corporation) of the popular show Countryfile, which is publicly accessible. The length of this show is about the same as the combined length as the all the other videos used in the video treatment.[3] After this video, we asked participants how much they would be willing to pay (in addition to what they usually pay) for milk with various levels of carbon equivalent emission reduction levels (the reduction levels are 15%, 30%, 50%, and 100% - carbon-neutral). Note that as the participants in this group did not receive any bundles. Hence, these questions no longer refer to any particular set of technologies. However, in this group, as well as in the other treatment groups, we do present a label when asking about WTP.

An example label is presented in Figure 4. Note that the colour of the label represents the degree of carbon emission reduction.

3.2 Ethical approval and pre-analysis plan

The experiment has received an ethical approval from the University of Sussex; approval number ER/AM799/4. The experiment in its design and implementation will follow the standard procedures, including pre-analysis plan, information sheets, informed consent forms, and institutional ethical approval. In addition, the information will be utilized in conformity with the anonymity criteria. The pre-analysis plan of the experiment can be found on the project website.[4]

4 Methodology

4.1 Data collected

We started off the survey with data collection on the participant's dairy consumption habits: how much milk was consumed, and at what price and what kind of milk was con-

[3]The video selected was called a Great Day Out and followed to men walking through the Brecon Beacons countryside. It can be accessed on youtube https://www.youtube.com/watch?v=Qui2cP493H0

[4]This site is available at OSF https://osf.io/2ygmz/!

sumed. We also elicited information about the participants' climate change concerns. We then proceeded with a section which elicited the participant's knowledge of the UK dairy system, and their preferences regarding dairy production. This was followed for a generic willingness-to-pay elicitation for climate smart milk which with various levels of carbon equivalent emission reduction levels (the reduction levels are 15%, 30%, 50%, and 100% - carbon-neutral). At this stage, the three treatment groups were split, and subjected to their respective treatments, with follow up comprehension questions. We then repeated our data collection of the willingness-to-pay, this time for the different technology bundles, and the knowledge and preferences regarding dairy production. We concluded the survey with a set of standard demographic questions, such as the participant's age, education, and income bracket.

Recall that the goal of the consumer experiment is to assess the consumer's knowledge, preference and willingness to pay for the climate smart dairy technologies we identified in prior stakeholder workshops, and, recognizing limits to external validity (to which we return in the conclusion), the role of three different styles of information provision, video, poster, and simply a label, on these.

In the remaining of this section, we first define the relevant variables, and then detail the regressions associated with this goal.

4.2 Variables

We have three key dependent variables: change in willingness to pay, a knowledge index, and a measure of consumer preferences as they relate to smart dairy.

Change in Willingness to Pay (WTP): This variable gauges the change in individual participants' WTP to pay for a unit of milk associated with varying percentages of reduction in carbon equivalent emissions. Specifically, the assessment involves the evaluation of WTP adjustments to emission reduction levels: 15%, 30%, 50%, and 100%.

Knowledge index:

The knowledge index quantifies the participant's understanding and awareness regarding the use of smart dairy technologies in the production of dairy. The index is calculated based on their score of nine knowledge questions and scored out of a maximum score of nine. Out of the nine knowledge questions, three questions are asked on each technology bundle i.e. three questions on nature, three on technology, and three on emission-reduction. Hence, the maximum score is three for each of the technology bundles. An example question of the technology bundle is: "Pedometers on cows: A) Measure their temperature. B) Count their steps, or C) Restrict their movement (Correct answer is B)." An example question of the nature bundle is: "Mob grazing implies: A) Over 100 cows in a field of less than one acre, B) Moving cows frequently to fresh pasture land, or C) Separating the male from the female calves in the field (Correct answer is B)." An example question of the emission-reduction bundle is: "When cows burp, they release mostly: A) Bad breath, B) Methane, or C) Carbon dioxide (correct answer B again).

Preference/Value index:

This variable encompasses the participants' stated preferences for particular attributes, features, or characteristics of dairy milk. The index is calculated based on their score of nine, what we termed, value questions. Each value question was scored on a Likert scale, from strong disagree to strongly agree (with a neutral and don't know option). Again, there are three questions associated with each of the technology bundles, i.e. three on nature, three on technology and three on emission-reduction. These will be aggregated by taking the average score (out of five), for each one of the bundles. Example statements include: "Dairy farmers have a duty to take care of the natural environment (nature based statement)", "Genetic selection is an important component of improved productivity for dairy farmers (technology based statement), and "Dairy farmers can alter a cow's diet to reduce greenhouse gas emissions (emission-reduction based statement).

Control variables:

- Gender: Gender refers to the gender of the participant – whether they are male, female, non-binary or other.

- Age: This is the age of the participants in years and is measured in a categorical fashion: below 25, between 25 and 35, between 35 and 45, between 45 and 55, and over 55 years old.
- Education: This refers to the level of education of the participant, and is measured in a categorical fashion as well: completed secondary education, completed college, currently an undergraduate student, currently a postgraduate student, completed an undergraduate degree, completed postgraduate/professional degree, or whether not mentioned.
- Household size: This refers to the number of members living in the household (under the same roof) including the participant. This does not include flat-mates or other students living in the house. For international students or staff, this excludes those family members living abroad.
- Income: This refers to the monthly household disposable income in sterling pounds (£). This is categorized into: Less than £500, between £500 and £1000, between £1000 and £1500, between £1500 and £2000, and more than £3000.
- Living arrangements: This variable gives us an idea about the participant's living arrangement, whether they live with parents, share an apartment, live alone, or have another arrangement.
- Farming and rural background: This variable details the background of the participant, whether they come from a farming background and/or a rural background.

4.3 Regression specifications

Hypothesis 1: Does the information treatment impact the WTP?

This hypothesis examines whether consumers' WTP changes as a result of the information treatments.

Denote by i the consumer; by j the experimental session, and by k the technology bundle. The dependent variable is the change in a consumer's willingness to pay (δWTP). The three treatments considered are the video treatment, the poster treatment and the label (active control).

We fit the following ANCOVA model and obtain estimated treatment effects as shown in equation 1 below, where: β_1 represents the effect of video treatment compared to the active control and β_2 represents the effect of poster treatment compared to the control. ϵ represents the random error term.

$$\Delta WTP_{ijk,post} = \beta_0 * LABEL_{ij} + \beta_1 * POSTER_{ij} + \beta_2 * VIDEO_{ij} + \gamma * \Delta WTP_{ijk,pre} + \epsilon_{ijk} \quad (1)$$

The standard errors in equation 1 above are clustered at the experimental session level j. In addition to aggregating the effects across all levels of emission reduction – 15%, 30%, 50%, and 100%, we will also estimate equation 1 separately for each level of emission reduction.

This equation is estimated with the full sample of 568 participants, but as the video and poster treatment each have three post treatment WTP estimates (one for each bundle), the total number of observations is 181 + 3 * 200 + 3 * 187 = 1342. The aggregate regression has a total number of observations of 1342 * 4 (one for each level), or 5,368.

Hypothesis 2: Does the information treatment impact knowledge and preferences?

This hypothesis examines whether consumers' knowledge and preferences change as a result of the information treatments. The regression equation in this hypothesis is similar to Equation 1.

$$K_{ijk,post} = \beta_0 * LABEL_{ij} + \beta_1 * POSTER_{ij} + \beta_2 * VIDEO_{ij} + \gamma * K_{ijk,pre} + \epsilon_{ijk} \quad (2)$$

$$V_{ijk,post} = \beta_0 * LABEL_{ij} + \beta_1 * POSTER_{ij} + \beta_2 * VIDEO_{ij} + \gamma * V_{ijk,pre} + \epsilon_{ijk} \quad (3)$$

Where K represents the knowledge index (out of 9), and V represents the value index (for each cluster, out of 5 following a Likert scale). In addition, we run the knowledge regression for each of the technology bundles (nature based, technology based, and emission-reduction based). This equation is again estimated with the full sample of 558 participants.

Hypothesis 3: Do consumers have preferences over technology bundles?

This hypothesis explores whether consumers have a preferences for specific technology bundles: the nature based, technology based, or emission-reduction based approaches. This is tested using post-intervention data of the video and poster groups, creating dummy variables indicating whether the change in WTP estimate refers to a nature, technology or emission-reduction bundle.

$$\Delta WTP_{ijk,post} = \beta_1 * Nature_{ijk} + \beta_2 * Technology_{ijk} + \beta_3 * Emission_{ijk} + \gamma \Delta WTP_{ijk,pre} + \epsilon_{ijk} \quad (4)$$

Again, we can we can estimate this equation separately for each level of emission reduction.

This equation is estimated with a sample of 387 participants, but as the video and poster treatment each have three post treatment WTP estimates (one for each bundle), the total number of observations is 3 * 387 = 1,1631. The aggregate regression has a total number of observations of 1,161 * 4 (one for each level), or 4,644.

Hypothesis 4: Does the information treatment affect these preferences over technology bundles?

This hypothesis assesses whether providing detailed visual information about each technology bundle, as we do on the video, affects the perceived value differences between the bundles. As the bundles are only presented to participants in the video and the poster group, this analysis essentially compares the poster treatment group with the video treatment group.

$$\Delta WTP_{ijk,post} = \beta_1 * N_{ijk} + \beta_2 * T_{ijk} + \beta_3 * E_{ijk} + \beta_6 * N_{ijk} * VIDEO_{ij} + \beta_7 * T_{ijk} * VIDEO_{ij} + \beta_8 * E_{ijk} * VIDEO_{ij} + \gamma \Delta WTP_{ijk,pre} + \epsilon_{ijk} \tag{5}$$

This equation is estimated using the sample of 387 participants. As the video and poster treatment each have three post treatment WTP estimates (one for each bundle), the total number of observations is 3 * 387 * 4 = 6,192.

4.4 Heterogeneity

In a future iteration of this paper, we plan to split participants by baseline milk consumption, and by the participant's concern about climate change.

4.5 A note on the analysis sample

We restrict the analysis sample to those participants who completed the full survey (23 participants did not), and participants who stated to drink milk (13 participants did not drink milk, despite this being an eligibility criteria in the experiment).

4.6 Balance test

In Table 3 we present the results of a balance tests. Column (1) presents the full sample, Column (2) the label (control) group, Column (3) the poster group and Column (4) the video group. Columns (5) and (6) test, respectively, for differences between the label (control) group and the poster and video group.

The first set of variables are possible control variables: male (0/1), age, graduate level education (0/1), income, farming background (0/1), rural background (0/1). The second set of variables are the dependent variables at baseline: Change in WTP (for all emission-reduction levels), the three knowledge indices, and the three preference indices.

Overall, we note a good balance between the various characteristics, and the baseline dependent variables. Exceptions are the education level, which is lower in the control label group, and preference for nature-based technologies, which is higher in the video group. In a future iteration of this paper, we intend to take into account these differences between the groups.

5 Analysis and Results

Prior to discussing the results, it should be noted that the results presented here are preliminary. We have yet to complete a formal outlier analysis, and screen the data for data entry errors and the like.

Table 4 and Table 5 present the results of hypothesis 1: The effect of the information interventions on the change in willingness-to-pay for climate smart dairy. Table 4 presents the results by emission reduction level while Table 5 presents the aggregate effects across the levels. The results in Table 4 indicate that the willingness-to-pay increases for all participants from pre-intervention to post-intervention. While this increase is greater in magnitude among the participants in the poster and video group, this difference is not statistically significant, barring for the 50% emission reduction level. The results are similar in Table 5. Note that the ANCOVA specification results in a high R-Squared across the board, ranging from 0.58 to 0.76.

Table 6 and Table 7 present the results of hypothesis 2: The effect of the information interventions on the knowledge and preferences of the participant. Table 6 presents the results on the aggregate and individual knowledge indices. Table 7 presents the result on the preference statements.

We note a strong effect of both poster and video interventions on the overall knowledge of the participants. Recall that knowledge was measured through a series of nine multiple-choice questions. The results in Table 6 indicate that while the knowledge pre- and post-intervention strongly correlate, the information-intervention effects are sizable and statistically significant. Belonging to the poster or video group increases one's overall knowledge by 3.0 to 3.5 points (Column (1)). The results in Columns (2) through (4) indicate that the participants learn most about the nature based and technology based smart dairy innovations.

We note an almost equally strong and but perhaps less sizable effect of the information interventions on preference statements regarding smart dairy in Table 7. Recall that these statements follow likert scales and range from 1 to 5, with the higher number capturing increased support for this type of technology. The information treatments increase support for emission-reduction based technologies, in particular, but have less of an impact on the nature based technologies and no statistically significant impact on technology based innovations.

These results appear to be in contrast with the effects on the willingness-to-pay. Indeed, one would expect a change in knowledge, and preferences to lead to a change in willingness-to-pay. We believe that part of the reason behind the null effects in Tables 4 and 5 might relate to the difficulty in the unit of measurement. Indeed, in the UK, milk can be purchased in many different sized bottles. In addition, we use both pints and liters. This results in a situation where some participants have a 1 pint bottle in mind, and others a 2 liter bottle. To tackle this situation, we decided, after significant pre-testing, to allow the participants to keep their unit in mind. So when we inquire about the milk price, this is by their unit. We then construct our willingness-to-pay question on this, and ask them how much more they are willing-to-pay for their usual bottle size. We noticed that despite this simplification, this exercise was complex for some. Further analysis will include a detailed outlier analysis, and perhaps a restriction to this sample who we can show have properly understood the formulation.

Table 8 and Table 9 present the results of hypothesis 3: Whether the participants have preferences over the three approaches. Recall that these tables are based on a reduced sample, as the three approaches were only presented to the participants in the video and the poster group. Hence these tables rely on post-intervention data from these two treatment groups only, and should be interpreted with caution. We use the willingness-to-pay as an overall measure for preferences in these tables. We note that while the nature based bundle overall receives more support, the ranking between the emission-reduction based and technology based depends on the level of emission reduction in Table 8. However, these differences are not statistically significant. Table 9 combines the different emission-reduction levels, and this appears to result in a further reversal of the ranking (which is yet again not statistically significant). Barring the issues with measurement of willingness-to-pay as noted above, we believe that a regression such as in Table 8 might fail to control for the heterogeneous effects across the different emission-levels.

Table 10 presents the results of hypothesis 4: Whether the information interventions affect preferences over the three approaches. Again, the same caveats of Table 9 apply. The estimate effects of the video treatment on willingness-to-pay for either technology or emission-reduction bundle are small and statistically insignificant. But the effect on the nature bundle is more sizable, and almost statistically significant.

6 Conclusion

We set up a laboratory experiment among 568 dairy consumers at a University in the South-East of England. We distinguish between three different avenues: a nature-based approach which increases carbon sequestration, a technology-based approach which improves system efficiency, and an emission-reduction-based approach which tackles emissions directly at the source. We set up a laboratory experiment with three information treatments – labels, posters, and videos. We collect data on knowledge, stated preferences and willingness-to-pay before and after the information interventions.

The preliminary results reveal a notable increase in willingness-to-pay for smart dairy milk from pre-intervention to post-intervention. This increase is more pronounced in the poster and video treatment groups, but only statistically significant when considering a sizable 50 percent emission reduction. While the information treatment effects on willingness-to-pay are generally insignificant, we identified a substantial impact of both video and poster interventions on participants' overall knowledge, with a specific focus on enhancing understanding of nature and technology-based smart dairy interventions. Additionally, the information treatments contribute to a heightened support for emission reduction technologies, displaying a comparatively weaker impact on nature-based technologies, as evidenced by stated preferences. Furthermore, the preference for technology bundles highlights a greater level of support for those incorporating nature-based solutions over alternatives solely focused on emission and technology. Notably, there is a substantial impact of the video treatment on the willingness-to-pay for nature-based bundles, whereas no similar effect is observed for emission and technology-based bundles.

In future iterations of this project, we aim to make three further additions. First, we aim to tackle three econometrics issues which have arisen: measurement error in the change in willingness-to-pay variable, heterogeneity in effects by emission-reduction levels, and the imbalance in some of the baseline variables. We believe that a more careful analysis on this front will allow us to reconcile some of the now seemingly contradictory results regarding effects on knowledge, stated preferences and revealed preferences (captured through willingness-to-pay). Second, we plan to expand our baseline analysis, by considering the correlates of knowledge, beliefs, and willingness-to-pay pre-intervention for all participants. This, together with a more extensive set of balance statistics, will allow us to make conclusions regarding the external validity of the paper. Third, we plan to check the robustness of our findings by generating the regression results with the main demographic controls. Fourth, we intend to further split the sample by baseline milk consumption, and by the participant's concern about climate change. This split will also feed into our discussion of external validity.

We recognise the limitations of laboratory experiments, especially when it comes to external validity. Naturally, the estimates of the effect sizes, and descriptive statistics, presented in this study are specific to the unique sample: Staff and students at a known-to-be progressive, and climate-forward, university in a relatively wealthy part of the United Kingdom, the South-East. However, this does not imply that the study has little external relevance. Indeed, in common with the other European nations, the UK is looking at a significant transformation of its dairy sector. While the UK might be unique now, post-Brexit, as being outside the Common Agricultural Plan of the European Union, the climate emergency was recognized, and reflected in the various policy documents and plans of the UK government. In addition, the method employed in this study, using stakeholder interviews to identify various approaches to smart dairy, and then the aggregation into bundles which are presented to consumer is unique to the project but can be applied in other contexts. We have made the design and data collection instruments available, as to facilitate the replication of this approach into other contexts. In terms of policy implications, the UK government acknowledges the pivotal role of consumers and farmers in transitioning to a low-carbon agri-food economy. The shifts in stated preferences, as evidenced in the study results, underscore the significance of interventions aimed at modifying consumer behaviour and influencing the demand for dairy products. Consequently, interventions that steer demand towards emission-reduction and nature-based technologies can indirectly prompt changes in farmers' practices, encouraging the adoption of more sustainable innovations and management methods. It is hence imperative to formulate and implement policies aligned with the preferences revealed in the study to support both consumers and farmers.

In early 2024, the UK government has announced an additional round of funding to bolster farm productivity, focusing on slurry management, and enhancing animal health and welfare. This initiative encompasses two types of funding: a) smaller capital grants under the Farming Equipment and Technology Fund and b) larger capital grants within the Farming Transformation Fund. The latter includes support for adult cattle housing, calf housing to address animal health and welfare, water management, and slurry infrastructure. The study's results allows us to refine these and future funding mechanisms for low-carbon farming and agricultural innovation by identifying specific strategies, derived from altering stated preferences, to promote technologies and practices. The preliminary findings offer valuable insights into the most effective mechanisms for influencing consumers towards more sustainable food choices. This, in turn, supports the adoption of sustainable innovations and management practices among dairy farmers.

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Figures and Tables

Figure 1: Poster nature-based

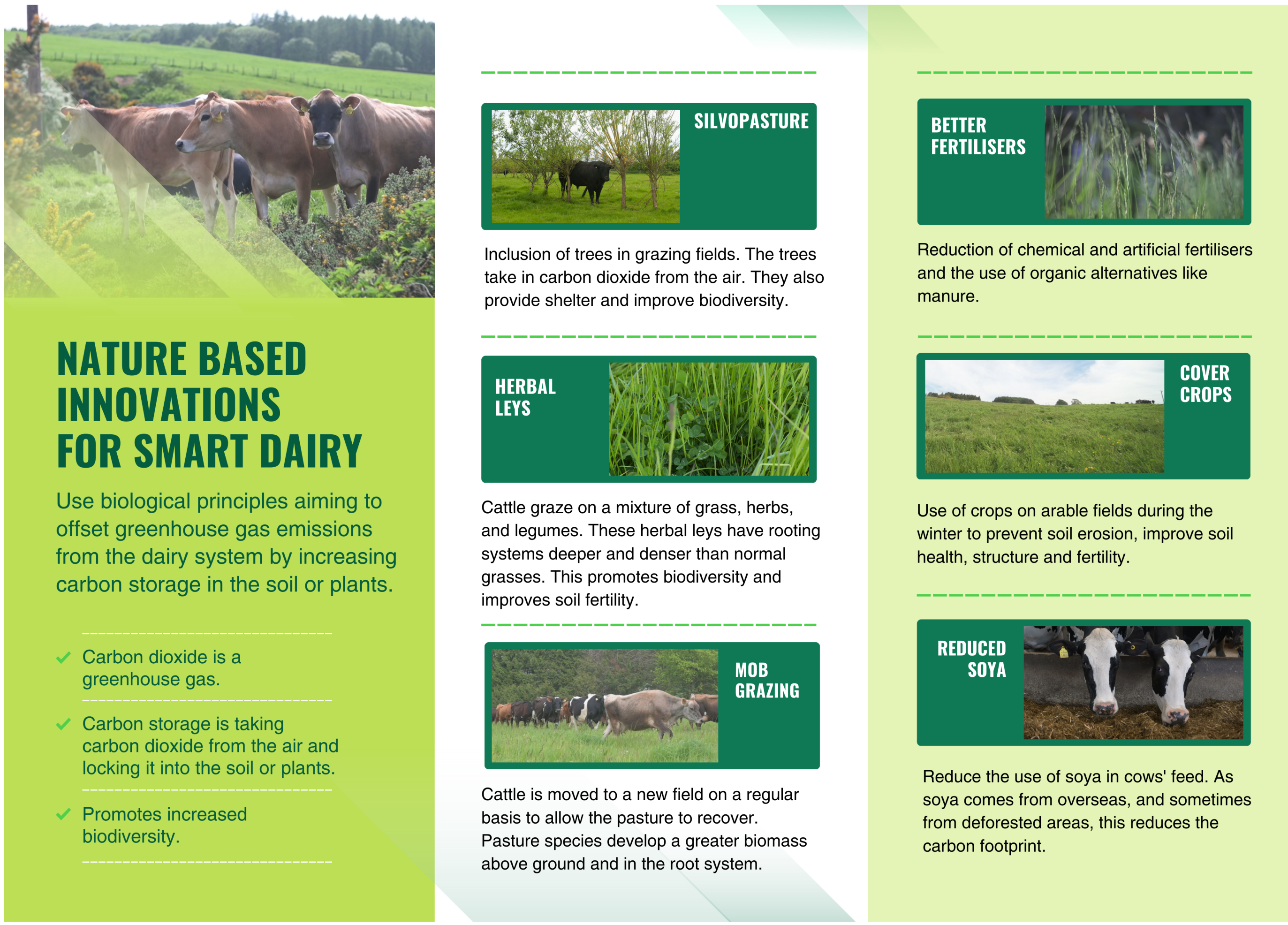

Figure 2: Poster technology-based

Figure 3: Poster methane-based

Figure 4: Example label used in all three treatment groups

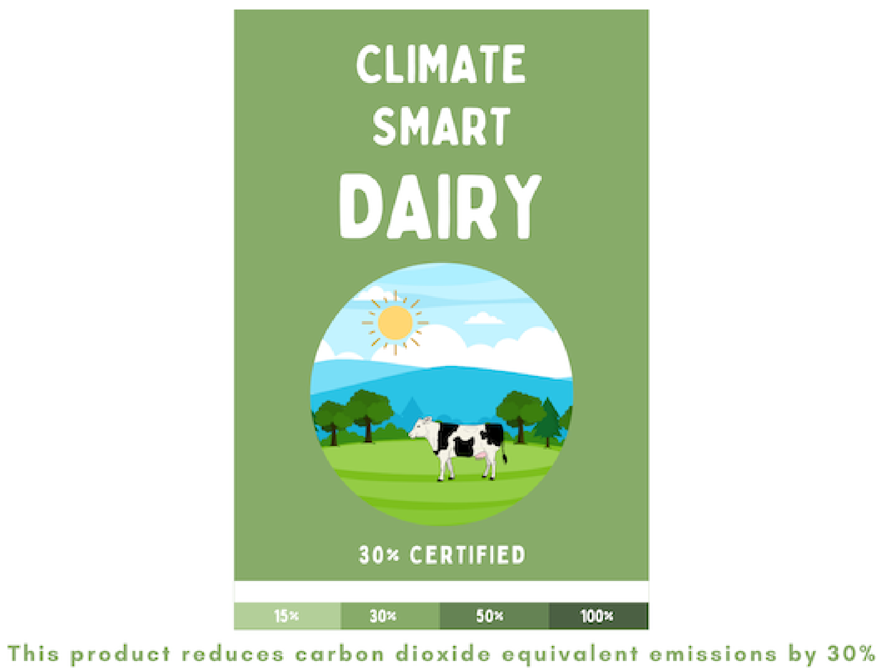

Table 1: Overview of the three bundles

Innovation	Nature	Technology	Emission-reduction
Reducing energy usage			
Heat recovery systems	no	yes	no
Reduced usage of farm inputs with high carbon footprints			
Reduce artificial fertiliser inputs			
Reduce inclusion of imported soya	yes	yes	no
Innovative waste management	no	no	yes
Addition of additives to farm yard slurry or manure	no	no	yes
Grazing management			
Inclusion of agroforestry or silvopasture	yes	no	no
Increased grazing time	yes	no	no
Improving soil health			
Mob grazing	yes	no	no
Cover crops	yes	no	no
Herbal leys	yes	no	no
Reducing the methane emitted by cows			
Feed additives	no	no	yes
Methane capture	no	no	yes
Animal related strategies			
Genetic management	no	yes	no
Precision Livestock Farming tools	no	yes	no

Note: This table provides an overview of the climate-smart technologies we considered in this study, and how we categorised them in three bundles: nature-based, technology-based and emission-reduction-based.

Table 2: Distribution of sample in each treatment

Treatment	Frequency	Percent
Label (Control)	181	32.87%
Poster	200	35.21%
Video	187	32.92%
Total	568	

Note: This table presents the distribution of the sample across treatments.

Table 3: Balance test

	(1) full sample	(2) label	(3) poster	(4) video	(5) label/poster	(6) label/video
male (0/1)	0.57	0.54	0.55	0.62	0.87	0.12
	(0.49)	(0.49)	(0.49)	(0.48)		
age	29	29	29	28	0.98	016
	(8.5)	(8.7)	(8.8)	(7.9)		
education (0/1)	0.60	0.30	0.77	0.71	0.00	0.00
	(0.48)	(0.46)	(0.41)	(0.45)		
income	909	890	887	951	0.95	0.33
	(629)	(858)	(661)	(637)		
farming background (0/1)	0.15	0.16	0.17	0.13	0.70	0.47
	(0.36)	(0.36)	(0.38)	(0.34)		
rural background (0/1)	0.26	0.30	0.23	0.25	0.13	0.26
	(0.44)	(0.46)	(0.42)	(0.43)		
change in WTP 15 percent	0.36	0.34	0.33	0.39	0.77	0.46
	(0.64)	(0.54)	(0.61)	(0.74)		
change in WTP 30 percent	0.62	0.55	0.61	0.70	0.55	0.17
	(1.06)	(0.78)	(1.11)	(1.22)		
change in WTP 50 percent	0.78	0.79	0.75	0.81	0.73	0.89
	(1.11)	(1.09)	(1.08)	(1.17)		
change in WTP 100 percent	1.14	1.06	1.09	1.29	0.85	0.13
	(1.48)	(1.24)	(1.53)	(1.63)		
knowledge emissions (0 to 3)	2.11	2.08	2.18	2.06	0.25	0.76
	(0.79)	(0.76)	(0.81)	(0.80)		
knowledge nature (0 to 3)	1.08	1.06	1.12	1.05	0.53	0.88
	(0.80)	(0.91)	(0.74)	(0.77)		
knowledge technology (0 to 3)	1.11	1.15	1.09	1.09	0.47	0.52
	(0.89)	(0.87)	(0.90)	(0.88)		
emission-reduction preferences (1-5)	3.92	3.90	3.97	3.87	0.42	0.78
	(0.87)	(0.92)	(0.84)	(0.85)		
nature preferences (1-5)	4.47	4.38	4.53	4.47	0.06	0.25
	(0.76)	(0.85)	(0.64)	(0.73)		
technology preferences (1-5)	3.18	3.20	3.22	3.11	0.80	0.30
	(0.80)	(0.85)	(0.74)	(0.81)		

Note: This table presents the balance test pre-intervention. Column (1) presents the full sample, Column (2) the label (control) group, Column (3) the poster group and Column (4) the video group. Columns (5) and (6) test, respectively, for differences between the label (control) group and the poster and video group. Education is coded as (=1) if graduate level degree or higher (including currently enrolled).

Table 4: The effect of the treatments on the willingness-to-pay (WTP)

	(1) WTP_15_post	(2) WTP_30_post	(3) WTP_50_post	(4) WTP_100_post
label	0.126***	0.120*	0.0841**	0.281***
	(0.0413)	(0.0614)	(0.0423)	(0.0775)
poster	0.151***	0.0883**	0.115***	0.250***
	(0.0281)	(0.0350)	(0.0432)	(0.0502)
video	0.147***	0.114***	0.217***	0.301***
	(0.0315)	(0.0239)	(0.0391)	(0.0512)
WTP_15	1.027***			
	(0.0516)			
WTP_30		1.007***		
		(0.0503)		
WTP_50			0.967***	
			(0.0531)	
WTP_100				0.848***
				(0.0449)
Observations	1,322	1,299	1,312	1,317
R-squared	0.590	0.786	0.806	0.794
label = poster	0.5869	0.6173	0.5665	0.6826
label = video	0.6787	0.9298	0.0206	0.7932

Note: This table presents the treatment effects on the willingness-to-pay using an ANCOVA specification. Standard errors clustered at the session level.*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: The effect of the treatments on the willingness-to-pay (WTP) - aggregate

	(1)
	WTP_post
label	0.160***
	(0.0298)
poster	0.159***
	(0.0205)
video	0.203***
	(0.0199)
WTP	0.925***
	(0.0274)
Observations	5,250
R-squared	0.766
label = poster	0.955
label = video	0.18

Note: This table presents the treatment effects on the willingness-to-pay using an ANCOVA specification, aggregating all emission reduction levels. Standard errors clustered at the session level.*** p<0.01, ** p<0.05, * p<0.1.

Table 6: The effect of the treatments on the knowledge index

	(1) knowledge_post	(2) knowledge_nature_post	(3) knowledge_technology_post	(4) knowledge_emission_post
label	1.516***	0.520***	0.580***	0.915***
	(0.189)	(0.0605)	(0.0616)	(0.0964)
poster	3.037***	1.047***	1.615***	0.877***
	(0.218)	(0.0693)	(0.0752)	(0.0960)
video	3.404***	1.065***	1.641***	1.183***
	(0.209)	(0.0715)	(0.0823)	(0.100)
knowledge	0.612***			
	(0.0405)			
knowledge_nature		0.476***		
		(0.0396)		
knowledge_technology			0.445***	
			(0.0364)	
knowledge_emission				0.536***
				(0.0380)
Observations	568	568	568	568
R-squared	0.938	0.805	0.854	0.912
label = poster	0.000	0.000	0.000	0.583
label = video	0.000	0.000	0.000	0.000

Note: This table presents the treatment effects on the knowledge index (out of 9) using an ANCOVA specification. Standard errors clustered at the session level.*** p<0.01, ** p<0.05, * p<0.1.

Table 7: The effect of the treatments on preferences

	(1) value_emission_post	(2) value_nature_post	(3) value_technology_post
label	2.295***	2.308***	0.884***
	(0.207)	(0.335)	(0.141)
poster	2.566***	2.450***	0.925***
	(0.206)	(0.335)	(0.135)
video	2.593***	2.374***	0.819***
	(0.205)	(0.331)	(0.137)
value_emission	0.469***		
	(0.0475)		
value_nature		0.492***	
		(0.0715)	
value_technology			0.719***
			(0.0393)
Observations	568	568	568
R-squared	0.976	0.984	0.958
label = poster	0.000	0.0235	0.552
label = video	0.000	0.2920	0.360

Note: This table presents the treatment effects on preferences using an ANCOVA specification. Preferences are measured, by bundle, using three Likert-scale questions (scale from 1 to 5, with 5 strongly support). Standard errors clustered at the session level.*** p<0.01, ** p<0.05, * p<0.1.

Table 8: Preferences for smart dairy production bundles

	(1) WTP_15_post	(2) WTP_30_post	(3) WTP_50_post	(4) WTP_100_post
nature	0.178***	0.102***	0.128***	0.316***
	(0.0421)	(0.0340)	(0.0374)	(0.0661)
technology	0.136***	0.0859**	0.145***	0.266***
	(0.0291)	(0.0369)	(0.0408)	(0.0532)
emission	0.140***	0.109***	0.131***	0.261***
	(0.0377)	(0.0387)	(0.0393)	(0.0582)
WTP_15	1.021***			
	(0.0547)			
WTP_30		1.009***		
		(0.0541)		
WTP_50			1.007***	
			(0.0451)	
WTP_100				0.842***
				(0.0480)
Observations	1,145	1,121	1,136	1,140
R-squared	0.589	0.808	0.817	0.799
nature = technology	0.409	0.706	0.711	0.4377
nature = emission-reduction	0.473	0.879	0.950	0.388
technology = emission-reduction	0.933	0.586	0.765	0.939

Note: This table uses the post-intervention data of the video and poster treatment groups to test for differential preferences for the three smart dairy production bundles. Standard errors clustered at the session level.*** p<0.01, ** p<0.05, * p<0.1.

Table 9: Preferences for smart dairy production bundles - aggregate

	WTP_post
nature	0.191***
	(0.0248)
technology	0.167***
	(0.0217)
emission-reduction	0.171***
	(0.0235)
WTP	0.929***
	(0.0289)
Observations	4,542
R-squared	0.773
nature = technology	0.358
nature = emission-reduction	0.445
technology = emission-reduction	0.878

Note: This table uses the post-intervention data of the video and poster treatment groups to test for differential preferences for the three smart dairy production bundles, aggregating all emission reduction levels. Standard errors clustered at the session level.*** p<0.01, ** p<0.05, * p<0.1.

Table 10: The effects on WTP for the production bundles

	(1)
	WTP_post
nature	0.390***
	(0.105)
technology	0.355***
	(0.0909)
emission-reduction	0.294***
	(0.0911)
WTP	0.711***
	(0.0846)
nature * video	0.127
	(0.0933)
technology * video	0.0247
	(0.0800)
emission-reduction * video	0.0897
	(0.0737)
Observations	4,853
R-squared	0.647

Note: This table uses data of the video and poster treatment groups to test for treatment effects on preferences for the three smart dairy production bundles. Standard errors clustered at the session level.*** p<0.01, ** p<0.05, * p<0.1.