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RESEARCH ARTICLE

Information provision and preferences for more sustainable dairy farming: Choice experimental evidence from Sweden

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Abstract

Dairy farming in Europe faces profound environmental, social, and economic sustainability challenges, which are of significant policy interest. These challenges support the need for a transition toward the uptake of more sustainable dairy farming practices. This paper examines the effects of an advisory instrument "balanced sustainability information" on farmers' preferences for more grass-based feeding systems using a between-subjects design and a discrete choice experiment among a sample of Swedish dairy farmers. Conceptually, we develop a state-dependent utility framework with Bayesian updating to motivate the impact pathway. Our results demonstrate that on average, balanced sustainability information has negligible effects on farmers' feed choices, which could be a consequence of opposing responses to the information, among others. Considering farmer heterogeneity based on their identities and prior knowledge, we find support for some evidence of treatment effects. Our findings highlight important and policy-relevant critical reflections about overoptimistic expectations of information provision as an instrument to nudge behavioral change toward more sustainable farming practices.

Keywords: Balanced sustainability information; behavior; discrete choice experiment; grass-based feeds; policy instrument

JEL Classification: D83; O33; Q18

Introduction

Dairy production in Europe is currently faced with profound sustainability challenges, which are of significant policy interest (Balaine et al., 2023; von Greyerz et al., 2023). In particular, there is an increasing awareness and concern about the severe environmental impacts of dairy production, including loss of biodiversity and emission of greenhouse gases (GHGs) associated with feed production and enteric fermentation in cows (Krizsan et al., 2021; Lindberg et al., 2021). There are also considerable social sustainability concerns in dairy production, for example, public concerns about animal welfare (Humble et al., 2021), and economic sustainability concerns, for example, low-profit margins at farms (Segerkvist et al., 2020). These challenges underline the strong consensus that a transformation toward more sustainable dairy farming and dairy-based food value chains is highly needed. While demand-side sustainability interventions such as dietary shifts from animal- to plant-sourced foods have received widespread attention, supply-side sustainability interventions relating to dairy farm production practices can also play a crucial role (Guyomard et al., 2021).

A growing body of research has identified livestock feeding systems that are centered on substituting human inedible feeds such as grasses and byproducts for feeds based on human edibles such as cereal and legume grains as one of the potential supply-side sustainability improvement strategies (Krizsan et al., 2021; Lindberg et al., 2021). Notably, dairy cows can convert forage into nutrient-rich foods for humans and marginal lands unsuitable for producing foods for humans can be used for forage production (Patel et al., 2017; von Greyerz et al., 2023). Hence, the uptake of feeding systems where dairy cows are fed rations with a relatively higher proportion of forage, especially grass silage and a relatively lower proportion of concentrates on a dry matter basis – that is, "more grass-based feeding systems" emerge as a promising supply-side sustainability intervention (Balaine et al., 2023; Karlsson et al., 2020). Indeed, from a sustainability lens, more grass-based feeding systems can reduce feed-food competition and the environmental footprints from feed production, improve animal welfare, grassland biodiversity, and related ecosystem services, among other farm-level and societal benefits (Lindberg et al., 2021; Tarekegn et al., 2021). Yet their uptake is still suboptimal in many European countries, especially in Sweden, where the ratio of forage to concentrate in dairy cow feeds is almost equal, on average over a lactation period, despite the potential for higher-forage feeds with up to 70% or more forage (Patel et al., 2017; Karlsson et al., 2020). To this end, a pertinent question is what policy instruments can drive dairy farmers' behavioral change toward more sustainable production practices using the example of more grass-based feeding systems.

This paper examines the impact of an advisory instrument "balanced sustainability information" on farmers' preferences for attributes of more grass-based feeding systems using data from a sample of Swedish dairy farmers. Specifically, we test whether the provision of balanced sustainability information about more grass-based feeding systems to farmers is sufficient to induce behavioral change toward more grass-based feeds. In addition, we test whether there are heterogeneous treatment effects in how farmers respond to the information. Conceptually, we develop a state-dependent expected utility model with Bayes' theorem to motivate how the information provision can affect dairy farmers' feed choices drawing on previous applications (e.g., Huffman et al., 2007; Lusk et al., 2004; Ortega et al., 2020; Rousu et al., 2002). We frame the treatment "balanced sustainability information about more grass-based feeding systems" as information covering the environmental, social, and economic sustainability impacts derived from grass-based feeding systems, including both the benefits and potential costs (or risks) associated with the feeding systems. As opposed to unbalanced information that focuses solely on potential benefits (costs) without highlighting potential costs (benefits) to farmers, balanced information signals greater credibility and fosters trust in information (Depositario et al., 2009; Martin et al., 2012). Also, balanced information offers a more holistic and objective picture of a behavior of interest to better ease information-related misperceptions of the behavior (Wuepper et al., 2019a). Furthermore, unbalanced information raises ethical concerns, where potential costs such as milk yield reduction may be associated with more grass-based feeds, but farmers are not properly informed.

Farmers' uptake of sustainable agricultural practices in Europe has been mainly supported through financial incentives as compensation for additional costs and/or revenue foregone in the provision of ecosystem services (Bougherara et al., 2021; Lapierre et al., 2023). However, despite substantial agri-environmental payments to farmers over the years as part of the second pillar of the European Union's (EU) Common Agricultural Policy (CAP)[1], the uptake of sustainable agricultural practices has been suboptimal, often lagging behind expectations (Chèze et al., 2020; Dessart et al., 2019). This partly supports the extant literature that argues that farmers' choices of production practices are not solely driven by pecuniary benefits but more often by nonpecuniary considerations[2] (Howley and Ocean, 2021; Leduc et al., 2023; Owusu-Sekyere et al., 2022). In addition, some studies show that an overly focus on financial incentives can crowd out the intrinsic motivation for applying sustainable practices (van Dijk et al., 2016; Zemo and Termansen, 2022). Given the aforementioned aspects and the budgetary burden of financial policy instruments, complementary low-cost instruments that can nudge behavior toward more sustainable food production are increasingly being considered (Dessart et al., 2019; Howley and Ocean, 2021; Wuepper et al., 2023), but their effects on preferences are not well understood.

The expanding body of research on farmers' willingness to accept sustainable agricultural practices or to participate in agri-environmental schemes has largely focused on financial policy instruments, assuming away the potential role of advisory policy instruments (Bougherara et al., 2021; Tienhaara et al., 2020). Often, it is assumed that farmers have perfect information about sustainable practices of interest, including the potential costs and benefits of applying the practices, which is not always the case (Chavas and Nauges, 2020). Yet, farmers' decisions partly relate to how they perceive the benefits and costs of applying alternative production practices – that is, to their subjective beliefs about the practices (Chèze et al., 2020; Dessart et al., 2019; Lapierre et al., 2023). In this view, the limited uptake of more grass-based feeds may relate to information constraints about the environmental, social, and economic sustainability impacts of grass-based feeds, but whether this is the case remains an empirical question. More importantly, the evidence base on effects of information interventions on behavior is mixed: positive effects (e.g., Lagerkvist et al., 2023; Lin and Nayga, 2022; Van Loo et al., 2020), negative effects (e.g., Caputo et al., 2023; Czajkowski et al., 2021; Ottersen et al., 2022), and null effects (e.g., Bazoche et al., 2023; Weingarten and Lagerkvist, 2023; Wuepper et al., 2019a). Thus, it remains unclear whether balanced sustainability information can affect farmers' feed choices, and whether the effects would vary along differences in farmer identities and prior knowledge.

We make policy-relevant contributions in three ways. First, we document whether the use of balanced sustainability information as a low-cost and easy-to-implement advisory policy instrument is sufficient to influence farmers toward more sustainable agricultural practices using the example of more grass-based feeds by impacting their preferences. Except for consumer studies on the effects of balanced information on food choices in different settings (e.g., Cao et al., 2021; Caputo, 2020; Depositario et al., 2009; McFadden and Huffman, 2017; Rousu et al., 2002; Wuepper et al., 2019a), our paper makes the first attempt to test the effects of balanced sustainability information provision among farmers. In this way, we provide relevant insights on balanced information framing effects to policy

[1]For example, dairy farmers in Sweden do receive some support, including cattle allowance, agri-environmental payments for grassland management, restoration and cultivation, and animal welfare allowance.

[2]A caveat worth mentioning is that the financial incentives provided by policy might not have been high enough to offset the negative effects on costs, foregone revenue, or other nonmonetary aspects associated with some sustainable practices, but this is outside the scope of this study.

makers and other agrifood system actors who are interested in identifying simple policy instruments that can influence farmer behavior regarding the uptake of more sustainable production practices. Second, in contrast to empirical studies that are limited to documenting only average treatment effects of information interventions (e.g., Caputo et al., 2023; Lemos et al., 2022; Ouvrard et al., 2023; Van Loo et al., 2020), we examine heterogeneous treatment effects of balanced sustainability information. Empirically, the latter is necessary as average treatment effects may be masked by substantial heterogeneity in treatment effects (Bazoche et al., 2023; Haaland et al., 2023), and from policy perspectives, insights from heterogeneous treatment effects can better inform policy targeting (Ortega et al., 2020; Cao et al., 2021; Lin and Nayga, 2022). Thus, our study context adds to the extant behavioral intervention literature that has reported heterogeneous effects, depending on the context and type of intervention (Hummel and Maedche, 2019; Mertens et al., 2022). Finally, our consideration of sustainability issues in farmer experimental settings with randomization adds to the burgeoning applications of choice experiments, often in consumer settings, which are designed to mimic real-world choices of decision makers under exogenous variation induced by randomization. This allows researchers to cleanly generate credible and policy-relevant inferences on what interventions work (or not) for sustainability transitions (e.g., Edenbrandt et al., 2021; Bazoche et al., 2023; Lagerkvist et al., 2023).

Conceptual framework

Following empirical applications in food-related choice experimental studies (e.g., Huffman et al., 2007; Lusk et al., 2004; Ortega et al., 2020; Rousu et al., 2002), we develop a state-dependent expected utility model to characterize farmers' preferences for attributes of more grass-based feeding systems. We complement the model with Bayes' theorem to motivate how the provision of balanced sustainability information to dairy farmers can nudge their choice behavior toward more grass-based feeding, by impacting their preferences for the feeding system's attributes. The model assumes that in decision-making under uncertainty or misperception about the potential outcomes (benefits and costs or risks) of more grass-based feeding, especially due to decision-relevant information constraints, farmers rely on their prior beliefs about grass-based feeding. In addition, Bayes' theorem implies that farmers may update their prior beliefs in response to balanced sustainability information about more grass-based feeding leading to well-informed decision-making. The extent of updating depends on the weight farmers place on the information vis-à-vis their prior beliefs.

We assume a utility-maximizing behavior, where the utility can be derived from both profit and other sustainability outcomes, for example, GHG emission reduction, improved animal welfare, etc., depending on the value that the farmer puts on those other sustainability outcomes. In the choice of dairy feeding system, where a farmer perceives utility only from farm profit (π), a state-dependent utility function for a utility-maximizing dairy farmer (n) who chooses to apply a more grass-based feeding system instead of a low-grass feeding system can be described as follows:

$$EU_n(\pi_n) = p(I_n)U_{ng}(\pi_n) + \left[1 - p(I_n)\right]U_{nb}(\pi_n) \tag{1}$$

where EU_n denotes the expected utility of dairy farmer n from applying a more grass-based feeding system. The farmer obtains U_{ng} if a good state (outcome) occurs or U_{nb} if a bad state (outcome) occurs, where $U_{ng} > U_{nb} > 0$[3]. $p(I_n)$ denotes the farmer's prior or perceived probability that applying a more grass-based feed would produce a good outcome. I_n represents the level of information the farmer has about more grass-based feeds, where $I_n \sim (-\infty, \infty)$. A large positive I_n indicates that overall, a farmer has positive or favorable information about more grass-based feeds – that is, the farmer

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perceives that the benefits outweigh the costs of more grass-based feeds. The reverse applies to a large negative I_n where the farmer perceives that the costs (e.g., milk yield reduction) outweigh the benefits of more grass-based feeding, especially where the farmer perceives the benefits to be limited to economic gains, reflected in high milk yield. In this case, the farmer underestimates the benefits. In sum, $p(I_n)$ is an increasing function of I_n.

Assuming farmers have unbalanced information about the environmental, social, and economic sustainability impacts from feeding systems, they are likely to misperceive the potential benefits and costs of more grass-based feeding systems (Chavas and Nauges, 2020; Dessart et al., 2019). Given this setting, the farmers are more likely to perceive a greater probability that a good outcome will occur with more grass-based feeding if exposed to balanced sustainability information about more grass-based feeding than farmers without the balanced sustainability information. With the introduction of balanced sustainability information into the feed choice decision environment, we assume that if farmers place a high weight on the information to sufficiently update their prior beliefs about more grass-based feeds, this would be reflected in their preferences. This leads to an updated state-dependent utility function:

$$EU_n(\pi_n, \pi_n^*) = p(I_n^*)U_{ng}(\pi_n + \pi_n^*) + \left[1 - p(I_n^*)\right]U_{nb}(\pi_n + \pi_n^*) \tag{2}$$

where π^* denotes the farmer's nonfinancial benefits associated with more grass-based feeds, including environmental benefits, for example, GHG emissions reduction, and social benefits, for example, animal welfare improvement. I_n^* denotes the new level of information the farmer has about more grass-based feeding systems in response to balanced sustainability information.

Following Rousu et al. (2002), we differentiate equation (2) with respect to I_n^*:

$$\frac{\partial EU(\pi_n, \pi_n^*)}{\partial I_n^*} = \frac{\overbrace{\partial p(I_n^*)}^{+} U_{ng}(\pi_n + \pi_n^*) + [\overbrace{1 - \partial p(I_n^*)}^{+}]U_{nb}(\pi_n + \pi_n^*)}{\partial I_n^*} > 0 \tag{3}$$

Based on equation (3), farmers with more access to balanced sustainability information are more likely to perceive a greater utility from applying more grass-based feeding systems, as they now become well-informed about environmental and social benefits of the feeding systems beyond economic benefits and costs. This assumes that farmers value environmental and social sustainability benefits and that through the information they realize how they can achieve those benefits from feeding systems. To this end, we hypothesize that:

H1: *Dairy farmers who are exposed to balanced sustainability information intervention will derive significantly larger marginal utilities from the attributes of grass-based feeding systems.*

A caveat to *H1* is that while balanced information provision is appealing, to warrant effects on preferences, it is likely that some farmers would exhibit opposing behavioral responses, which on average could lead to negligible effects of the information (Wuepper et al., 2019a)[3]. Thus, some farmers may not process the information optimally in line with

[3]For instance, despite the ample potential benefits, some farmers may attach more weight to the costs (risks) than to the benefits, which may decrease their perceived utility of more grass-based feeding. Some may willfully ignore the information if it conflicts with their farming objectives relating to high milk yield (Golman et al., 2017; Nordström et al., 2023). Some may interpret it as confirming their erroneous prior beliefs, that is, confirmatory bias (Rabin and Schrag, 1999),

Bayesian theorem (McFadden and Lusk, 2015). Depending on their prior beliefs, subgroups of farmers may update their beliefs in different directions in response to the information, leading to a muted average treatment effect (Haaland et al., 2023). In this sense, we consider the potential heterogeneous treatment effects of balanced information provision. Drawing on identity economics theory (Akerlof and Kranton, 2010) and empirical applications (e.g., Howley and Ocean, 2021; Zemo and Termansen, 2022), farmer identity "the extent to which a farmer identifies with a sustainable practice" is an intrinsic motivating factor for the uptake of such practice beyond financial gains, as such a farmer derives identity utility from strongly identifying with the practice. In our study setting, it is reasonable to assume that dairy farmers with weak pro-environmental and pro-social identities – that is, those who weakly identify with the environmental and social sustainability impacts of their feeding systems are more likely to misperceive grass-based feeding systems than farmers with stronger pro-environmental and pro-social identities. Assuming such misperceptions of grass-based feeds stem from poorly informed prior beliefs (Huffman et al., 2007), we hypothesize that:

H2: *Dairy farmers with weak pro-environmental and pro-social identities will be more influenced by balanced sustainability information intervention.*

A growing stream of empirical studies highlights that information provision treatment effects are often only effective (or more effective) among respondents with low prior knowledge of the behavior of interest (Huffman et al., 2007; Lin and Nayga, 2022; Lusk et al., 2004). This aligns with the knowledge-deficit theory, which posits that individuals' suboptimal decisions regarding a behavior mainly relate to a lack of (weak) knowledge of the consequences of the behavior and that knowledge transfer works best among those who face the knowledge deficit (Schultz, 2002; Weingarten et al., 2022). Intuitively, we expect dairy farmers who are less knowledgeable about more grass-based feeding systems to be more likely to misperceive the feeding systems than more knowledgeable farmers. Using farmer agricultural education and participation in grass-related feed training as proxies for prior knowledge, we hypothesize that:

H3a: *Dairy farmers who have not previously participated in grass-related feed training will be more influenced by balanced sustainability information intervention.*

H3b: *Dairy farmers who have no agricultural education will be more influenced by balanced sustainability information intervention.*

Materials and methods

Treatment randomization

To assess the effects of balanced sustainability information on dairy farmers' preferences regarding attributes of more grass-based feeding systems, we used a between-subjects design, where respondents are randomly assigned into two groups: half to a treatment group and half to a control group. The design is better suited for our study setting where shorter surveys are more feasible and allows us to better reduce possible confounding between information treatment effects and learning or fatigue effects often associated with within-sample designs and longer surveys (Vanermen et al., 2021). We opted for equal allocation of respondents to treatment and control, and individual-level randomization to maximize power (Glennerster and Takavarasha, 2013). Dairy farmers assigned to the treatment group received balanced sustainability information about more grass-based feeding in a text format, as part of the introductory information preceding the survey, while farmers in the control group did not receive the information. Thus, we vary one aspect of the information set provided to the farmers, as expected of information provision experiments (see Haaland et al., 2023). The balanced sustainability information was framed based on empirical literature on dairy feeding and sustainability (e.g., Segerkvist et al., 2020; Guyomard et al., 2021; Krizsan et al., 2021; Lindberg et al., 2021; Patel et al., 2017; Ryan et al., 2016; Tarekegn et al., 2021, van den Pol-van Dasselaar et al., 2020) and discussions with animal scientists during the study design. The information jointly highlights the environmental, social, and economic sustainability impacts associated with grass-based feeding, including both potential benefits and costs (or risks) in a concise and comprehensible manner to potentially lead to better-informed choices. The treatment farmers are better able to gauge the impacts of their feeding systems from the three sustainability dimensions, noting the ample potential private and societal benefits vis-à-vis the costs associated with their feed choices to allow updating (or reinforcing) their priors if they place higher weight on the information. The information script for the treatment group reads as follows (Figure 1).

Research has shown that dairy cows in Sweden can be fed feed rations with up to 70% grass silage (human-inedible feed) on average over a lactation period without adversely affecting their milk production. From a sustainability lens, the adoption of 'a more grass-based feed ration' on your dairy farm can offer multiple benefits to you and society, including economic, environmental and social sustainability benefits.

In terms of economic sustainability, 'a more grass-based feed ration' can improve the profitability of your farm, mainly through the reduction of concentrate feed cost, and potential income support and price premium, which can offset any possible reduction in milk yield. However, income support and premium price are not necessarily certain economic outcomes in the future, due to possible policy changes.

In terms of environmental sustainability, 'a more grass-based feed ration' can reduce your farm's GHG emissions, preserve your farm's biological diversity and improve carbon sequestration, among others in line with Sweden's environmental goals.

In terms of social sustainability, 'a more grass-based feed ration' can reduce societal concerns about the use of human-edible crops to feed animals, improve the welfare and health of your dairy cattle, and improve your farm's landscape value and feed self-sufficiency, among other benefits.

Figure 1. Balanced sustainability information.

Data

We used data from a sample of specialized Swedish dairy farmers, which was collected through an online survey. Online administration of surveys is common and considered an efficient survey mode among farmers in Sweden, where about 98% of the population has internet access (Internetstiftelsen, 2019). Also, it addresses potential social desirability bias that is associated with face-to-face interviews (Mariel et al., 2021). The survey sample was based on the official register of 2,795 dairy farms across the 21 counties in Sweden, administered by Statistics Sweden. We received access to 2,313 dairy farms that had registered contact information through e-mail or text message. Farms owned by institutions were excluded from the sample, and part of the sample was used for the study's pilot survey, which was conducted in July 2022 with complete responses from 33 farmers.

This resulted in a final sample of 2,048 dairy farmers for the main survey with 1,024 farmers randomly assigned to a treatment group and 1,024 to a control group. The survey consists of three parts. The first part includes farmer and farm characteristics, the second part covers the choice experiment, and the third covers measures of farmer attitudes and identities. Following the identity measurement scale put forward by Terry et al. (1999), we use five-point bipolar measurement items for environmental, social, and economic identities in the survey (see Table A1 in the appendix). The scale has been widely applied in the empirical literature (e.g., van Dijk et al., 2016; Zemo and Termansen, 2022).

The survey was implemented from late August to early October 2022 through a marketing research company to better preserve the anonymity of farmers. The company invited farmers to participate in the survey through text messages and emails containing the survey aims and a link to the survey. After three reminders, we received complete survey responses from 375 farmers, representing an effective response rate of 18.3%, which is similar to a recent farmer survey in Sweden (Owusu-Sekyere et al., 2022). Notably, our sample is not significantly different from the target population based on available data from Statistics Sweden: farm size, annual working hours, and counties of the specialized dairy farmers (see Table A2). In addition, following de Bekker-Grob et al. (2015) discrete choice experiment (DCE) sample size calculation using our DCE design and pilot data, our final sample is sufficient to identify statistically significant parameter estimates per treatment.

Table 2 shows descriptive statistics of our sample and results of the balance tests. The full sample is 82% male, with an average age of 52 years and the share of respondents with an agricultural education is 60%. Dairy herd size is on average 119 cows and the share of certified organic farms is 23% in the sample, which is similar to the population's average herd size of 102 cows and share of organic farms of 18% in 2021, as reported in the Swedish Board of Agriculture's statistical compilation (Swedish Board of Agriculture, 2022). Overall, there are no statistically significant differences in farmer and farm characteristics across the treatment and control groups, which supports the validity of our randomization. The latter also applies to the identity indicators (Table A1). We observe a similar survey response time across the treatment and control groups, which allays concerns regarding fatigue effects, inattention to the treatment information, and data quality in general.

Discrete choice experiment

We used a DCE to elicit dairy farmers' preferences for attributes of more grass-based feeding systems. The DCE mimics real-world feed choice situations by having farmers repeatedly choose between two proposed hypothetical options of more grass-based feed rations, with the possibility to choose neither in each choice situation. The hypothetical feed ration options are described by different attributes, reflecting different sustainability impacts associated with them, that is, utilities from environmental, social, and economic sustainability dimensions associated with feeds. Based on a detailed review of dairy farming and sustainability literature (e.g., Segerkvist et al., 2020; Guyomard et al., 2021; Krizsan et al., 2021; Patel et al., 2017; Ryan et al., 2016; Tarekegn et al., 2021, van den Pol-van Dasselaar et al., 2020, etc.), we first identified potential attributes for the study. The attributes were further discussed with three natural scientists with different specializations (animal nutrition, sustainability of food systems, and animal health and environment), about 15 seminar participants in an agricultural and food economics research group and with a Swedish dairy industry representative. A final set of six relevant attributes were selected: GHG emissions, animal welfare, feed cost, biodiversity, feed self-sufficiency and milk yield, and their corresponding levels, as described in Table 1. The attributes are evenly

Table 1. Attributes and attribute levels

Attribute	Description	Attribute levels
GHG emissions	Impact on GHG emissions of the proposed dairy feeds compared with a farm's current feed ration. It is expressed as a percentage reduction in the average carbon footprint per kilogram of milk produced by a dairy cow.	0%, 10%, and 20% reduction in emission per kg of milk
Animal welfare	Impact on dairy cow welfare of the proposed dairy feeds compared with a farm's current feed.	No improvement, low improvement, and high improvement
Feed cost	Impact on feed cost of the proposed dairy feeds compared with a farm's current feed. It is expressed as a percentage reduction in the average feed cost per kilogram of milk.	0%, 10%, and 20% reduction in feed cost per kg of milk
Biodiversity	Impact on diversity of plant and animal species of the proposed dairy feeds compared with a farm's current feed.	No improvement, low improvement, and high improvement
Feed self-sufficiency	Impact on feed self-sufficiency of the proposed dairy feeds compared with a farm's current feed. It is expressed as a percentage increase in the proportion of farm-produced feedstuff for dairy cows.	0%, 10%, and 20% increase in feed self-sufficiency per farm
Milk yield	Impact on milk yields of proposed dairy feeds compared with a farm's current feed. It is expressed as a percentage reduction in the average annual milk production of a dairy cow.[1]	0%, 10%, and 20% reduction in milk yield per cow

[1]This represents the payment vehicle in the DCE, as it reflects a cost (forgone revenue) to the farmer in accepting more grass-based feeding and the farmer is expected to experience a negative utility from the attribute, as described in Mariel et al. (2021) and applied in Dissanayake and Vidanage (2023).

spread across the sustainability dimensions, that is, two attributes represent environmental, social, and economic sustainability impacts of alternative feed rations, respectively. The attributes and their levels were presented to farmers in a text format during the DCE implementation.

We designed mutually exclusive hypothetical options of grass-based feed rations, that is, choice sets using a sequential Bayesian D-efficient design in *Ngene* software to improve the precision of parameter estimates (D error = 0.012, A error = 0.080) (Scarpa et al. 2013). In the first step, we generated an orthogonal design and implemented a pilot DCE based on the design. Secondly, we estimated a multinomial logit model using the pilot data. Lastly, we used the parameter estimates as Bayesian priors in generating the Bayesian efficient design[4]. The design produced 24 paired choice sets randomly blocked into 4 blocks of 6 choice sets to limit respondents' fatigue. Each choice set had two hypothetical options of grass-based feed rations and an opt-out option to better depict real-world feed

[4]Besides relying on the pilot for priors, we leveraged the pilot to refine the survey instrument by rewording some aspects of the instrument that respondents had difficulty comprehending and dropping some questions to improve the data quality (Athnos et al., 2022).

Table 2. Summary statistics of farm(er) characteristics and balance tests

Variable	Description	Full	Treatment	Control	*p*-Value[1]
Gender	1 if farmer is a male, 0 female	0.82 /	0.84 /	0.82 /	0.788
Age	Age of farmer (years)	51.93	52.18	51.71	0.708
		(12.19)	(12.36)	(12.05)	
Agric_education	1 if farmer has a secondary and/or university education in agriculture, 0 otherwise	0.60 /	0.59 /	0.61 /	0.735
Dairy_experience	Years of dairy farming	23.41	23.78	23.08	0.614
		(13.54)	(13.61)	(13.51)	
Dairy_herd_size	Number of dairy cows	119.19	126.38	112.84	0.422
		(162.63)	(207.63)	(108.44)	
Grazing_area	Total grazing land area (hectares)	66.46 (93.22)	66.75 (100.22)	66.22 (86.82)	0.956
Conventional_system	1 if farmer operates a conventional dairy production system, 0 otherwise	0.76 /	0.78 /	0.73 /	0.257
Grass-based_feed	1 if farmer uses a more grass-based feed,[2] 0 otherwise	0.21 /	0.19 /	0.22 /	0.585
Training	1 if the farmer has participated in any feed-related training, 0 otherwise	0.21 /	0.18 /	0.24 /	0.124
Milk_yield	Average energy-corrected milk yield per cow (kg/year)	10322.87 (1917.17)	10372.35 (1966.11)	10279.11 (1876.71)	0.639
Dairy_income_share	Proportion of household's total disposable income (after tax) from dairy farming (%)	77.58 (26.51)	77.75 (26.17)	77.45 (26.87)	0.909
Farm location					
Southern_Sweden	Located in southern Sweden	0.17 /	0.16 /	0.18 /	
Central_Sweden	Located in Central Sweden	0.57 /	0.59 /	0.55 /	0.743
Northern_Sweden	Located in Northern Sweden	0.26 /	0.25 /	0.27 /	
Survey response time					
Slow	More than 60 minutes	0.25 /	0.23 /	0.27 /	

(*Continued*)

Table 2. (*Continued*)

Variable	Description	Full	Treatment	Control	p-Value[1]
Modest	10 to 60 minutes	0.72 /	0.73 /	0.70 /	0.634
Fast	Less than 10 minutes	0.03	0.04	0.03	
Observations		375	176	199	

[1]p-Values from tests of equality of means between treatment and control groups using two-sided t-test and Chi-squared test for continuous and categorical variables, respectively.
[2]Dairy cow feeding with over 70% forage, on average over a lactation period and at least six grazing hours daily during the grazing season. Standard deviations are reported in parentheses.

choices, where a farmer can choose any of the proposed options or retain his/her current feed ration (Hensher et al., 2015). See a sample of the choice set in the appendix. As described in Scarpa and Rose (2008), we evaluate the performance of the design by comparing its efficiency criteria with the ex post efficiency criteria derived using the parameter estimates from our main survey data (D error = 0.014, A error = 0.106). Taking the ratio of our initial and ex post design criteria together, our design performs well with an efficiency of 86% and 75% for D- and A-errors, respectively. To better reduce the hypothetical bias inherent in DCE, we included a cheap talk script augmented with an opt-out reminder in the instructions preceding the choice questions, as explained in Haghani et al. (2021).[5]

Econometric estimation

Faced with available options of feed rations, we assume that a utility-maximizing dairy farmer would choose the option that, given the combination of attributes, offers the highest expected utility level, consistent with random utility theory (McFadden, 1974). In our study setting, the overall utility derived from a given feed option is the sum of the utilities derived from the attributes of the option, reflecting the environmental, social, and economic utilities associated with the feed choice (Lancaster, 1966). Hence, the utility U_{ijs} that a dairy farmer n $(n = 1, \ldots, N)$ gains from choosing option i $(i = 1, \ldots, I)$ of a feed ration in a choice set t $(t = 1, \ldots, T)$ can be decomposed into a deterministic (V_{nit}) and a stochastic component (ε_{nit}):

$$U_{nit} = V_{nit} + \varepsilon_{nit} = ASC + \boldsymbol{\beta} x_{nit} + \varepsilon_{nit} \tag{4}$$

where ASC refers to alternative-specific constant, which reflects the relative utility farmers attach to the status quo option. $\boldsymbol{x}_{nit}$ is a vector of attributes describing the feed options, with a corresponding vector of marginal utilities $\boldsymbol{\beta}$. ε_{nit} is assumed to be an independently and identically distributed $(i.i.d)$ extreme value. Eq. (4) assumes nonrandom $\boldsymbol{\beta}$. To allow for heterogeneity in preferences across dairy farmers, $\boldsymbol{\beta}$ is transformed into $\boldsymbol{\beta} + \boldsymbol{\sigma_n}$, leading to a mixed logit (MXL) model in preference space parameterization (Hensher et al., 2015):

$$U_{nit} = ASC + (\boldsymbol{\beta} + \boldsymbol{\sigma}_n)\boldsymbol{x}_{nit} + \varepsilon_{nit} \tag{5}$$

where $\boldsymbol{\sigma}_n$ denotes a deviation or spread of preferences among respondents around the mean marginal utilities. For the treatment and control groups, we estimate MXL models

[5]While we employed ex ante hypothetical bias mitigation techniques, we acknowledge that ex post assessment of the sensitivity of our results to possible hypothetical bias as applied in Wuepper et al. (2019b) would have produced more insights. However, we are unable to implement such sensitivity test due to data limitations.

based on Eq. (5) to assess heterogeneous preferences for different feed-related sustainability attributes by their treatment status. To better estimate the treatment effects in terms of trade-offs between utilities derived from the attributes, willingness to pay (WTP) space utility model parameterization offers a direct estimation of trade-offs while ensuring a finite variance in the distribution of the trade-off values (Scarpa et al., 2008). Following empirical applications in consumer food choices (e.g., Edenbrandt et al., 2021; Lagerkvist et al., 2023; Wuepper et al., 2019a), we estimate a pooled MXL model in WTP space with the inclusion of treatment-by-attribute interactions to test the average effects of the treatment on the trade-offs that dairy farmers are willing to make in their feed choices:

$$U_{nit} = \alpha_n[-c_{nit} + ASC + (\boldsymbol{\beta} + \boldsymbol{\sigma}_n)\boldsymbol{x}_{nit} + \boldsymbol{\delta}(\boldsymbol{x}_{nit} * treat)] + \varepsilon_{nit} \tag{6}$$

where c_{nit} denotes the attribute, milk yield reduction, representing a cost attribute. $\alpha_n$is milk yield scale parameter, which allows us to directly compute the trade-offs that dairy farmers are willing to make in their feed choices in terms of milk yield per cow, that is, the marginal willingness to forego some milk yield for additional utility from each attribute of interest. *treat* is a binary treatment variable that takes a value of 1 for dairy farmers in the treatment group and 0 for those in the control group. $\boldsymbol{\delta}$ is a vector of parameter estimates of interest that capture the average effects of the treatment (*H1*). Furthermore, we extend Eq. (6) with the inclusion of three-way interaction terms between treatment and attributes with farmer identities and with farmer prior knowledge to test for heterogeneous effects of the treatment by farmer identities (ϑ_n) (*H2*) and prior knowledge (Z_n) (*H3*), as discussed in the conceptual framework.

Testing *H2* is empirically challenging because directly incorporating indicators of socio-psychological constructs such as farmer identities into a choice model raises concerns about potential measurement errors and endogeneity bias (Daly et al., 2012; Mariel et al., 2021). Thus, for *H2*, we estimate a hybrid choice model, which combines an MXL model with a latent variable model to address potential measurement errors and endogeneity concerns, as applied in previous studies (Owusu-Sekyere et al., 2022; Zemo and Termansen, 2022). The latent variable model consists of measurement and structural functions that are jointly estimated using multiple indicators and multiple causes framework to produce factor scores on latent identity constructs, which are incorporated into the MXL model as interaction with treatment and attributes. For brevity, we do not provide extensive details of the hybrid choice model (see Appendix A.2 for the methodological details).

As a robustness check, we estimate the average treatment effects of balanced sustainability information using an alternative model specification. We compute the trade-offs that dairy farmers are willing to make in their feed choices in terms of milk yield per cow using the parametric bootstrapping method of Krinsky and Robb (1986) based on estimates of MXL in preference space parameterization. Thereafter, we test the differences in trade-offs across the treatment and control groups using the complete combinatorial test of Poe et al. (2005), as applied in previous studies (Caputo et al., 2023; Lin and Nayga, 2022). Except for the estimation associated with the Poe test in Stata, all models were estimated in R using the "logitr" package developed by Helveston (2023).

Results and discussion

Preferences by treatment status

Table 3 reports the results of MXL model estimates of farmers' preferences for different sustainability attributes of dairy feeds. Across the treatment and control groups, the coefficients of milk yield reduction are negative and statistically significant, as expected,

Table 3. Results of MXL models in preference space by treatment status

	(1) Treatment sample	(2) Control sample
Mean		
ASC	0.768***	0.711***
	(0.264)	(0.266)
GHG emissions reduction	0.036***	0.027***
	(0.009)	(0.009)
Animal welfare improvement: low	0.887***	1.049***
	(0.164)	(0.203)
Animal welfare improvement: high	1.299***	1.283***
	(0.202)	(0.212)
Feed cost reduction	0.029***	0.036***
	(0.011)	(0.011)
Biodiversity improvement: low	−0.268*	−0.346***
	(0.152)	(0.133)
Biodiversity improvement: high	0.227	0.382*
	(0.180)	(0.219)
Feed self-sufficiency	−0.005	−0.010
	(0.009)	(0.008)
Milk yield reduction	−0.074***	−0.069***
	(0.011)	(0.013)
Standard deviation		
GHG emissions reduction	0.059***	0.065***
	(0.012)	(0.014)
Animal welfare improvement: low	0.762***	0.596**
	(0.292)	(0.263)
Animal welfare: high	1.058***	1.573***
	(0.365)	(0.399)
Feed cost reduction	0.090***	0.088***
	(0.012)	(0.012)
Biodiversity improvement: low	0.230	0.085
	(0.350)	(0.088)
Biodiversity improvement: high	−0.022	−0.983***
	(0.188)	(0.267)

(*Continued*)

Table 3. (*Continued*)

	(1) Treatment sample	(2) Control sample
Feed self-sufficiency	0.042***	0.056***
	(0.018)	(0.016)
N	3168.000	3582.000
Log Likelihood	−970.124	−1098.121
Akaike information criterion	1972.248	2228.242
Bayesian information criterion	2069.221	2327.181

Notes: Standard errors are in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$.

which indicates that on average, respondents are averse to dairy feeds associated with reductions in milk yield. Similarly, the coefficients of GHG emission reduction, low and high improvement in animal welfare, and feed cost reduction are positive and statistically significant, indicating that respondents derive higher utilities from dairy feeds associated with these feed-related sustainability attributes, irrespective of their treatment status. These results suggest that while more grass-based feeds are appealing from a sustainability perspective, notably GHG emission reduction, improvement in animal welfare, and feed cost reduction can increase the likelihood of accepting grass-based feeds, potential milk yield reductions (and revenue losses) could reduce the uptake of the feeds. Unexpectedly, the respondents are indifferent to feed self-sufficiency and perceive a low improvement in biodiversity relative to no improvement, as unappealing in their feed choices, albeit only a high improvement in biodiversity is slightly appealing to the control group, which suggests a limited interest in biodiversity improvement. The statistically significant standard deviation estimates show that preferences for feed-related sustainability attributes vary substantially across the respondents, particularly in the control group. On average, respondents across the treatment and control groups appear to derive higher utility from their current feed rations relative to the proposed more grass-based feeds, as indicated by the positively significant coefficients of the Alternative Specific Constants (ASCs).

Average treatment effects of balanced sustainability information

Table 4 shows the results of MXL models in WTP space for the pooled sample with treatment interactions using milk yield reduction, as the scaling variable. The mean attribute coefficients are estimates of the mean marginal willingness to forgo some milk yield per cow for additional utilities from other feed-related sustainability attributes. The positive and statistically significant coefficients of GHG emission reduction, low and high improvement in animal welfare, and feed cost reduction indicate that respondents across the treatment and control groups are strongly willing to trade off some milk yield per cow for these attributes. In particular, respondents are willing to trade off varying amounts of milk yield per cow – on average, about 17% milk yield per cow for high improvements in animal welfare relative to the reference level and less than 1% milk yield per cow for a 1% reduction in GHG emission. This suggests that on average, farmers place a higher value on improvements in animal welfare in their feed choices compared to other feed-related

Table 4. Results of MXL models in WTP space for pooled sample with treatment interactions

	(1) Mean	(2) Standard deviation
Main effects		
ASC	9.241***	
	(3.730)	
GHG emissions reduction	0.391***	−0.918***
	(0.119)	(0.136)
Animal welfare: low improvement	14.444***	9.270***
	(1.961)	(3.006)
Animal welfare: high improvement	16.725***	−18.549***
	(2.963)	(4.223)
Feed cost reduction	0.491***	−1.265***
	(0.134)	(0.156)
Biodiversity: low improvement	−4.967***	−0.242
	(1.721)	(0.526)
Biodiversity: high improvement	5.112*	8.598***
	(2.842)	(2.945)
Feed self-sufficiency	−0.085	−0.679***
	(0.1405)	(0.416)
Milk yield reduction (scale parameter)	−0.073***	
	(0.008)	
Treatment effects		
ASC × Treat	2.519	
	(5.015)	
GHG emissions reduction × Treat	0.133	
	(0.152)	
Animal welfare: low improvement × Treat	−1.402	
	(2.700)	
Animal welfare: high improvement × Treat	2.663	
	(3.560)	
Feed cost reduction × Treat	−0.122	
	(0.192)	
Biodiversity: low improvement × Treat	1.730	
	(2.670)	
Biodiversity: high improvement × Treat	−1.421	

(*Continued*)

Table 4. (*Continued*)

	(1) Mean	(2) Standard deviation
	(3.118)	
Feed self-sufficiency × Treat	0.026	
	(0.138)	
N	6750.000	
Log likelihood	−2068.302	
Akaike information criterion	4184.603	
Bayesian information criterion	4321.852	

Notes: Treat is a binary variable that takes a value of 1 for farmers in the treatment group and 0 otherwise. Standard errors are in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$

sustainability attributes. This aligns with previous studies which have found that farmers place significant value on animal welfare and animal welfare-improving practices in Sweden (Hansson et al., 2018; Hansson and Lagerkvist, 2015; Owusu-Sekyere et al., 2022).

More importantly, we focus on the estimates of the mean treatment effects. The estimated coefficients of the treatment interaction with GHG emission reduction, high improvement in animal welfare, low improvement in biodiversity, and feed self-sufficiency are positive, which indicates that on average, the provision of the information tends to increase the treated farmers' marginal willingness to forgo some milk yield per cow for additional utilities from these attributes. However, the effect sizes are in general small and are not statistically significant. Rather surprisingly, the information tends to decrease the treated farmers' marginal willingness to forgo milk yield per cow for additional utilities associated with low improvement in animal welfare, feed cost reduction, and high improvement in biodiversity.

Overall, our results point to null average effects of the provision of balanced sustainability information on farmers' preferences, which is inconsistent with the motivation underlying *H1* in our conceptual framework. As a robustness check, the results of the Poe et al. (2005) test in Table A3 in the appendix also reveal that the trade-offs that farmers are willing to make across the treatment and control groups are not significantly different. The results align with Wuepper et al. (2019a) who reported negligible effects of balanced sustainability information on consumer preferences and other studies that have documented null effects of (unbalanced) sustainability information interventions (e.g., Bazoche et al., 2023; Carfora et al., 2019; Weingarten and Lagerkvist, 2023). However, descriptive information on how farmers perceive more grass-based feeds, which was elicited after the DCE suggests that the treatment may have contributed to updating (or reinforcing) the beliefs of some of the treated farmers in favor of more grass-based feeds (Table A4 in the appendix). However, we do not make causal claims given that we are unable to analyze prior beliefs vis-à-vis posterior beliefs of farmers due to data limitations.

A possible explanation for our null average effects could be due to potential opposing effects of the information intervention: some farmers may update their prior beliefs in favor of (or against) more grass-based feeds and others may reinforce their prior beliefs in favor of (or against) more grass-based feeds. That is, some individuals may not process the information optimally in line with Bayesian theorem, as discussed in McFadden and Lusk

(2015). Relatedly, some farmers may be open to the information while others may willfully ignore the information if it challenges their prior beliefs about maintaining high-yielding milk feed rations, which could lead to cognitive dissonance, as posited in previous studies (Golman et al., 2017; Nordström et al., 2023). This is often the case where the value placed on prior beliefs outweighs the information, which can motivate non-Bayesian behaviors (Bénabou and Tirole, 2016). Similarly, it could be that some misinterpret it as supporting their prior beliefs, a classic case of confirmatory bias in the behavioral economics literature (Rabin and Schrag, 1999). Finally, while we carefully framed the balanced information, the negligible effects could partly be a consequence of the information contents if farmers do not consider the contents very informative. The latter is plausible for those farmers who are more likely to perceive a simple and direct information on what farming practices to switch into, based on a strong scientific consensus, as the basis for considering whether information contents are valuable.

Heterogeneous treatment effects of balanced sustainability information

Table 5 shows the heterogeneous treatment effects by farmer environmental and social identities using estimates of the three-way interaction terms between attributes, treatment, and farmer identities. Except for the interaction terms between high biodiversity, treatment, and social identity, the estimated coefficients of the interaction terms are positive, which indicates that on average, farmers with stronger pro-environmental and pro-social identities are more likely influenced by the information than farmers with weak identities. Notably, farmers with stronger pro-environmental identities are willing to trade off more milk yield per cow, about 6% for improvement in biodiversity, and the effect is statistically significant. While we expect farmers with weak identities to be more responsive, as they are more likely to hold misperceived prior information about more grass-based feeding, it appears the intervention primarily functions to reinforce the prior beliefs of farmers with strong identities. This suggests that the intervention resonates more with farmers who have strong intrinsic motivation for applying sustainable practices. Overall, our result mirrors Ottersen et al. (2022) who reported that respondents with strong animal welfare concerns are more responsive to information about animal welfare consequences of meat consumption. However, the result is in contrast with consumer studies that found that respondents with weak environmental concerns are more responsive to pro-environmental information (Graham and Abrahamse, 2017; Weingarten et al., 2022). The latter could be because our study focused on farmers whose behavioral responses may be different from consumers.

Table 6 shows the heterogeneous treatment effects by farmer prior knowledge, proxied by whether the farmer has previously participated in grass-related training and whether the farmer has an agricultural education. The coefficients of the three-way interaction terms between attributes, treatment, and grass-related training are largely negative, indicating that farmers without grass-related training (limited knowledge of grass-based feeding) are more likely responsive to the information than farmers with grass-related training. This suggests that the information treatment effects partly depend on the level of farmer prior knowledge about grass-based feeding, which makes sense, as information interventions tailored to respondents who face (more) knowledge deficit (or preference uncertainty) are potentially more effective (Schultz 2002; Ortega et al., 2020). However, the effects are only statistically significant and relatively small with respect to GHG emissions and feed cost reductions. In addition, the effects are partly consistent with the three-way interaction terms between attributes, treatment, and agricultural education, where some of the coefficients are negative and others are positive. Notably, farmers with a general agricultural education tend to place more weight on animal welfare and feed self-sufficiency than farmers with no agricultural education, which is consistent with Lin and

Table 5. Results of MXL models in WTP space showing how the impact of balanced sustainability information varies by farmer identities (ϑ_n)

	(1) Interaction with treatment and environmental identity	(2) Interaction with treatment and social identity
ASC × Treat × ϑ_n	10.064	4.244
	(6.532)	(7.838)
GHG emissions reduction × Treat × ϑ_n	0.128	0.053
	(0.208)	(0.249)
Animal welfare: low improvement × Treat × ϑ_n	4.513	1.198
	(3.837)	(3.915)
Animal welfare: high improvement × Treat × ϑ_n	1.284	4.195
	(4.549)	(5.465)
Feed cost reduction × Treat × ϑ_n	0.347	0.158
	(0.223)	(0.299)
Biodiversity: low improvement × Treat × ϑ_n	6.336**	0.719
	(3.152)	(4.070)
Biodiversity: high improvement × Treat × ϑ_n	1.173	−3.412
	(3.925)	(5.271)
Feed self-sufficiency × Treat × ϑ_n	0.118	0.187
	(0.189)	(0.022)
N	6750.000	6750.000
Log likelihood	−2039.076	−2040.135
Akaike information criterion	4158.153	4160.270
Bayesian information criterion	4386.900	4389.018

Notes: Treat is a binary variable that takes a value of 1 for farmers in the treatment arm and 0 otherwise. Identity is a continuous variable captured by the scores for the environmental and social identity constructs, where higher scores imply stronger pro-environmental and pro-social farmer identities. Standard errors are in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Full model estimates are available in the appendix.

Nayga (2022) who find that better-educated individuals are more responsive to pro-environmental information. However, the effects are only statistically significant with respect to feed self-sufficiency. The observed divergence between the results in columns (1) and (2) could be because grass-related training is a better proxy for prior knowledge about grass-based feeding than general agricultural education.

Conclusion and implications

This study examined the effects of balanced sustainability information provision on farmers' preferences for attributes of more grass-based feeding systems for their dairy

Table 6. Results of MXL model in WTP space showing how the impact of balanced sustainability information varies by farmer prior knowledge (Z_n)

	(1) Interaction with treatment and grass-related training	(2) Interaction with treatment and agricultural education
ASC × Treat × Z_n	−28.063**	7.107
	(12.348)	(10.294)
GHG emissions reduction × Treat × Z_n	−0.856**	−0.225
	(0.390)	(0.327)
Animal welfare: low improvement × Treat × Z_n	−7.245	5.565
	(7.463)	(5.627)
Animal welfare: high improvement × Treat × Z_n	−9.130	3.001
	(8.116)	(7.259)
Feed cost reduction × Treat × Z_n	−0.989**	−0.171
	(0.497)	(0.390)
Biodiversity: low improvement × Treat × Z_n	−3.395	6.149
	(6.184)	(5.356)
Biodiversity: high improvement × Treat × Z_n	−8.874	−5.017
	(7.279)	(6.248)
Feed self-sufficiency × Treat × Z_n	0.198	0.576**
	(0.375)	(0.290)
	(0.184)	(0.175)
N	6750.000	6750.000
Log likelihood	−2059.517	−2061.230
Akaike information criterion	4199.033	4202.459
Bayesian information criterion	4427.781	4431.207

Notes: Treat is a binary variable that takes a value of 1 for farmers in the treatment arm and 0 otherwise. Grass-related training is a binary variable that takes a value of 1 if farmer has previously participated in any grass-related feed training and 0 otherwise. Agricultural education is a binary variable that takes a value of 1 if farmer has an agricultural education and 0 otherwise. Standard errors are in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Full model estimates are available in the appendix.

cows, reflecting environmental, social, and economic sustainability impacts associated with dairy feeds. To motivate how the information can affect farmers' feed choices, we developed a state-dependent utility framework with Bayesian updating, and we applied the framework using a between-subjects design and a choice experiment among a sample of Swedish dairy farmers.

In general, our findings demonstrate that across the treatment and control groups, dairy farmers are sensitive to feed-related environmental, social, and economic sustainability impacts in their feed choices, particularly to animal welfare-related impacts.

The strong interest in animal welfare could be a consequence of the strict Swedish animal welfare legislation relative to the EU welfare legislation, as explained in Hansson et al. (2018), genuine farmer interest in the wellbeing of their animals, and/or increasing societal pressure about animal welfare, etc. (Guyomard et al., 2021). More importantly, our findings reveal that the balanced information provision has limited effects on farmers' preferences. Among other factors, this could be a consequence of asymmetric responses to the information. Furthermore, our findings reveal suggestive evidence of heterogeneous treatment effects by farmer identities and prior knowledge, which indicates that while the balanced information effect is on average negligible, there are subgroups of farmers that are likely to benefit from the information, especially farmers with stronger pro-environmental identities and farmers who likely have less prior knowledge about more grass-based feeds. This suggests that future research on farmer-related information policy evaluation should always explore treatment heterogeneity, beyond average effects.

We provide some critical reflections of our findings for policy and the literature on information interventions, particularly about overoptimistic expectations of information treatment effects. First, while information-related policy instruments are often cheap and easy to implement, introducing balanced sustainability information would be insufficient to impact preferences and influence behavior toward more grass-based feeding systems, especially in the short term, as in our study. This challenges the standard economic assumption underlying most information interventions – that is, individuals would immediately process decision-relevant information, update their (misperceived) prior beliefs, and refine their preferences. However, from a behavioral perspective, the processes might be much slower (see Wuepper et al. (2023) for a recent review covering farmer behavioral deviations from neoclassical economic assumptions). This suggests that inducing behavior toward more sustainable practices may require policy approaches that go deeper, more to personal values, which can be partly reflected in how messages are framed, as documented in previous studies on consumers' food choices (Graham and Abrahamse, 2017; Lagerkvist et al., 2023). Second, the use of a one-time provision of balanced sustainability information without sufficient time intervals to process the information may have contributed to the limited treatment effects. To allay this concern, the use of repeated information interventions over a considerable time as applied in a few consumer studies (e.g., Carfora et al., 2019; Ottersen et al., 2022) may be more relevant to better understand farmer behavioral responses, but this is open to further research in farmer settings.

Third, while we adopt the classical assumption that respondents would be willing to seek decision-relevant information and incorporate it into their decision-making processes leading to well-informed preferences, from behavioral economics, some respondents may actively avoid such information with strategic rationales (Golman et al., 2017). For example, it could be that some farmers avoid information about sustainability impacts of dairy farms, and the plausible motivations could be that such information signals a negative image about dairy farms or conflicts with their prior beliefs about maintaining high-yielding milk feed rations, among others. The latter could induce cognitive dissonance, and thus by an information avoidance behavior, the respondents do not have to experience the dissonance. There are emerging empirical applications of active information avoidance behavior in economic literature (e.g., Edenbrandt et al., 2021; Nordström et al., 2023). Yet applications in farmer settings are scarce. Future research on farmers' responsiveness to information-related interventions should empirically explore the role of active information avoidance.

Finally, our study further demonstrates the role of economic experiments in testing the effectiveness of potential agri-environmental policy instruments, which lend credence to the growing recognition of experiments in the EU's CAP evaluation (Lefebvre et al., 2021). While we focused on a balanced information instrument, feed choices, and dairy farmers, more experiments are needed on how different primary producers trade off sustainability attributes in their production decisions under different (mix of) policy instruments and contexts to better inform policy initiatives for different farmer types toward transitioning to more sustainable food production. We acknowledge the methodological limitation of our study in empirically testing the potential mechanisms explaining the limited average treatment effects, which could arise if respondents update their prior beliefs in different directions in response to information. However, we are unable to explore the prior and posterior beliefs of farmers and other channels to better interrogate our conceptual framework, as suggested in Haaland et al. (2023) due to data limitations stemming from the need to make our survey short, especially considering the treatment group where the treatment can lead to longer survey time and fatigue effects. Given the research and policy importance of understanding mechanisms underlying (lack of) information treatment effects, future studies in settings where longer surveys are feasible should collect more relevant data relating to prior and posterior beliefs, information avoidance, and trust in information, among others toward providing useful insights.

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