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# Policy Schemes for More Sustainable Dairy Farming: The Role of Financial Instruments and Policy Implementation Modes

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## ABSTRACT

Dairy farming is faced with environmental, social and economic sustainability challenges, which call for the uptake of more sustainable farming practices. Policy schemes involving public and private sectors can support the uptake of more sustainable farming practices through the provision of incentives to farmers if designed appropriately. However, empirical research in designing such policy schemes is scarce. This paper examines dairy farmers' preferences for policy attributes in environmental compensation schemes for more grass-based feeding systems. Using data from a discrete choice experiment in Sweden and a hybrid latent class model, we find that while size of financial compensation matters, farmers' likelihood of participation in grass-based feeding schemes is also driven by how the financial compensation is designed and by non-financial attributes of the policy schemes. Notably, we find three distinct groups of farmers who differ in their likelihood of participating and exhibit heterogeneous preferences for schemes with private versus public sector-led implementation mode, and direct subsidy payment versus consumer price premium and tax relief. Furthermore, findings demonstrate that behavioral factors, including farmer attitudes toward different forms of compensation and risk aversion, partly explain the observed heterogeneous preferences. Overall, our findings highlight the need to accommodate preference heterogeneity in policy design to improve participation, especially in settings where the transition to more grass-based feeding is challenging for farmers.

**JEL Classification:** D91, O33, Q18

## 1 | Introduction

Dairy farming is traditionally notable for nutrient-rich foods, livelihood opportunities and non-provisioning ecosystem services in Europe (Leroy et al. 2024; Zira et al. 2025). However, it is currently facing profound sustainability challenges, which are generating increased interest among researchers, policymakers, consumers and other food system actors. In particular, dairy farms are faced with environmental sustainability challenges, including loss of biodiversity and emission

of greenhouse gases from feed production processes and enteric fermentation (Le Gloux et al. 2023). There are also ethical and social sustainability concerns, such as welfare of animals and feed-food competition between humans and animals (Krizsan et al. 2021), and economic sustainability concerns, relating to high feed costs and volatile output prices (Balaine et al. 2023). These concerns underpin the growing consensus regarding the need for adoption of more sustainable dairy farming practices, which is a potential production-side sustainability strategy while also advocating for dietary shifts to more

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plant-sourced foods, as a consumption-side sustainability strategy (Herzon et al. 2023).

Optimizing livestock feeding systems through the substitution of human inedible feed resources, such as grasses and byproducts for human edibles can be leveraged as a production-side sustainability improvement strategy (Lindberg et al. 2021; Zira et al. 2025). Such feeding systems, “*more grass-based feeding systems*”, where dairy cows are fed rations with a higher proportion of forage, especially grass silage and a lower proportion of concentrates on a dry matter basis are receiving attention (Krizsan et al. 2021; Le Gloux et al. 2023).<sup>1</sup> This is due to the inherent ability of cows to upcycle grasses into nutrient-dense foods for human consumption. From a sustainability lens, grass as feed is interesting as it can be grown on marginal lands, which can allay societal concerns regarding food-feed competition (Karlsson et al. 2020; Bystricky et al. 2023). However, grass production can result in increased competition for land if done on arable lands and if not grown as part of an optimal crop rotation. In addition, *more grass-based feeding systems* can reduce environmental footprints associated with production, import and processing of grain-based concentrate feeds, and offer improvements in animal welfare, grassland biodiversity, and other ecosystem services (Krizsan et al. 2021; Balaine et al. 2023). Yet, intensive dairy farming persists in many EU countries, including Sweden, the empirical basis for this study, where dairy cow feed rations have a relatively equal proportion of forage and concentrates over the lactation period (Patel et al. 2017; Danne and Musshoff 2017; Le Gloux et al. 2023)<sup>2</sup>. As with other Northern European countries, the agro-climatic conditions in Sweden, where all-year-round grazing is not possible, make more grass-based feeding challenging and less appealing to farmers without appropriate policy incentives. In this setting, it can also reduce yields, making it even less appealing. How best to encourage the uptake of *more grass-based feeding systems* remains a highly policy-relevant question to achieve more sustainable dairy farming.

In this paper, we assess *ex-ante* farmers’ preferences in the design of a *more grass-based feeding scheme*, as a hypothetical voluntary environmental compensation scheme to support the uptake of more grass-based feeding systems, using data from a discrete choice experiment among a sample of Swedish dairy farmers. Specifically, we investigate farmers’ willingness to participate in grass-based feeding policy schemes, and how they respond to policy schemes with direct subsidy payment versus alternative modes of financial compensation and with private versus public sector-led modes of implementation of non-financial policy instruments, including social reward and advisory support. Also, we analyze the underlying drivers of farmers’ preferences, taking into account economic and behavioral drivers of decision-making. We apply standard and hybrid latent class models. The hybrid latent model deals with potential measurement errors and endogeneity bias associated with incorporating indicators of latent constructs into standard choice models (Mariel and Arata 2022; Oyinbo and Hansson 2024).

Previous studies on farmer preferences for attributes of policy schemes to support uptake of sustainable practices often focus on only one type of financial compensation, assuming a one-size-fits-all approach and are unable to provide insights into how farmers trade off utilities from different types of financial compensation.

A large strand of literature considered compensation through direct subsidy payments (e.g., Christensen et al. 2011; Vaissière et al. 2018; Bougherara et al. 2021; Lapierre et al. 2023). This aligns with agri-environmental schemes in the EU’s Common Agricultural Policy (CAP), which have received substantial budgetary allocations over the years, yet, farmers’ participation in the schemes has been suboptimal (Schaub et al. 2023). Few studies have explored private sector initiatives such as price premiums in the supply chain (Danne and Musshoff 2017; Schreiner and Hess 2017; Schröter and Mergenthaler 2021). We are unaware of studies that have considered the use of tax relief in farmer settings and how farmers perceive different modes of financial compensation in policy schemes in highlighting their preferences for how dairy sustainability transformation should be financially incentivized. Beyond financial incentives, few studies have examined how non-financial compensation in the form of societal recognition of farmers shapes decisions regarding participation in policy schemes, with mixed results (Trenholm et al. 2017; Banerjee et al. 2021; Howley and Ocean 2021). Furthermore, some studies have examined how the provision of technical assistance in policy schemes relates to farmer decisions, with mixed results (e.g., Hasler et al. 2019; Šumrada et al. 2022). While the mixed results could be a consequence of how social reward and advisory support are implemented, empirical studies in this regard are scarce. In sum, whether the use of direct subsidy versus alternative modes of financial compensation and implementing policy instruments by public versus private sector actors matter for farmers’ preferences remains an empirical question.

Beyond *ex-ante* understanding of farmers’ preferences for design characteristics of policy schemes, unpacking the underlying drivers of their preferences can better inform effective policy design (Schulze et al. 2024). In this regard, there is a growing interest in enriching neoclassical economic assumptions of rationality with insights from behavioral economics to better explain farmer decisions (Palm-Forster and Messer 2021; Schaub et al. 2023). Yet, most empirical studies on policy schemes (Vaissière et al. 2018; Hasler et al. 2019; Šumrada et al. 2022; Canessa et al. 2023) focus on observable farmer and farm characteristics in explaining preference heterogeneity, without explicitly considering behavioral factors. Few studies have considered the role of behavioral factors such as attitude towards a behavior and risk aversion (e.g., Mariel and Arata 2022; Lapierre et al. 2023). Despite theoretical motivation for considering time preference in intertemporal choice settings, where farmer choices often pay off slowly over time (Wuepper et al. 2023), the role of time preference in policy scheme choices has received limited attention. Acknowledging the context and case-specific nature of behavioral drivers of policy schemes (see review by Schaub et al. 2023), it remains unclear whether attitude towards a behavior, risk attitude and time preference matter for farmer decisions regarding grass-based feeding schemes.

Our paper makes policy-relevant contributions in three ways. First, we provide novel and highly policy-relevant insights to the literature on sustainable agriculture and environmental schemes by showing how farmers respond to policy schemes with compensation via different financial instruments, beyond direct subsidy and implementation of policies such as social reward and advisory support via public vis-à-vis private sector actors. In this sense, we provide evidence on how policy scheme design

can make a difference and build on the large body of empirical studies on policy schemes that are often limited to direct subsidy payment and public sector-led policy implementation mode for encouraging uptake of sustainable practices (e.g., Vaissière et al. 2018; Bougherara et al. 2021; Lapiere et al. 2023; Lefebvre et al. 2025). Second, we add behavioral insights to the burgeoning literature on motivations underlying farmer decisions regarding policy schemes by exploring whether different farmer attitudes, risk, and time preferences meaningfully explain preferences for grass-based feeding policy schemes. This addresses a policy-relevant limitation of previous studies on policy schemes in sustainable agricultural settings (e.g., Hasler et al. 2019; Šumrada et al. 2022; Canessa et al. 2023) that are unable to explain how scheme choices relate to behavioral factors, beyond the traditional economic analyses of farmer decision-making.

Third, we assess dairy farmers' preferences in the design of a potential policy scheme tailored to more grass-based feeding systems in an *ex-ante* quantitative way and in a setting where agro-climatic conditions make such feeding systems unappealing without appropriate policy incentives. This provides evidence base on how scheme design can be optimized by taking into account farmers' heterogeneous preferences to better stimulate their acceptance of such schemes and deliver their expected results, especially in settings where the transition to more grass-based feeding is challenging for farmers. In this way, we build on the limited economic studies on grass-based feeds and programs that are largely *ex-post* evaluation studies (e.g., Balaine et al. 2023; Bystricky et al. 2023; Le Gloux et al. 2023) and do not consider *ex-ante* farmer preferences in policy scheme design for more sustainable dairy farming.

## 2 | Materials and Methods

### 2.1 | Data and Descriptive Statistics

We used data from a sample of dairy farmers across the 21 counties in Sweden. The data were collected through an online survey, which was implemented from the last week of May to the first week of July 2023. The data collection was implemented using a marketing research company that has no stake in the study to preserve the confidentiality and anonymity of farmers. The survey sample was based on the official register of 2150 specialized dairy farms in Sweden obtained from Statistics Sweden, a government authority that manages statistical information. From the register, we excluded institutionally owned farms and farms that do not have contact details, such as email and phone number. This resulted in a final sample of 2133 specialized dairy farms. From the sample, we implemented a pilot survey in May 2023 with data from 35 farmers before the main survey. The data from the pilot informed priors for the design of the choice experiment, and the feedback from the pilot informed the rewording of some questions that respondents had difficulty comprehending towards improving the data quality. We invited 2098 farmers to participate in the survey through text messages and emails introducing the aims of the survey and a link to the questionnaire. The questionnaire had three parts: a discrete choice experiment; farmer and farm characteristics; and farmer attitudes, risk, and time preferences (see a copy of the questionnaire in the [online supplementary material](#)). After three rounds of reminders, a total

of 972 farmers started the survey, 624 dropped out of the survey and 348 completed the survey, which resulted in a completion rate of about 17%. This is close to the completion rate of about 18% reported in a recent study among Swedish dairy farmers (Oyinbo and Hansson 2024). About 60% of the farmers who dropped out of the survey did so after giving consent to participate while others dropped out at different parts of the survey<sup>3</sup>. To compensate farmers for their time in participating in the survey, we provided two lottery tickets valued at 60 SEK to each farmer.

The distribution of our sample by county aligns with that of the target population (see Figure S2). In terms of farm size, annual working hours, and geographic location, our sample is not significantly different from the target population (see Table S1). In terms of attrition, 624 farmers dropped out, that is, started but did not complete the survey, resulting in an attrition rate of 64%<sup>4</sup>. Using available data, those who dropped out do not differ significantly from those who completed the survey, indicating that attrition is not associated with observable farmer and farm characteristics but might be related to other non-observed characteristics (Table S2). Table 1 shows descriptive statistics of our sample. The sample is 16% female, has an average age of 53 years, and the share of respondents with an agricultural education is 51%. The sample's dairy herd size is on average 112 cows, and the share of certified organic farms is 22% in the sample. The herd size is similar to the population's average herd size of 110 cows, but the share of organic farms is higher than the population's share of 15% in 2023, as reported in the Swedish Board of Agriculture's statistical compilation (Swedish Board of Agriculture 2024b).

### 2.2 | Discrete Choice Experiment

As applied in different agricultural and food settings (Adere et al. 2024; Jada and van den Berg 2024; Nian et al. 2025; Xu et al. 2025; Varziri et al. 2025), we used a discrete choice experiment (DCE) to elicit farmers' preferences for attributes of hypothetical policy schemes aimed at encouraging uptake of more grass-based dairy feed rations. In the DCE, respondents were presented with a sequence of six choice tasks, each having two proposed policy schemes for more grass-based dairy feeding systems and an opt-out option, if a respondent did not want to participate in the proposed schemes. The hypothetical policy schemes are described by policy-related characteristics, referred to as attributes and the levels of the attributes, which vary over the hypothetical policy options. We identified a pool of potential policy-related attributes for the study based on a review of the literature (e.g., Christensen et al. 2011; Danne and Musshoff 2017; Schreiner and Hess 2017; Vaissière et al. 2018; Banerjee et al. 2021; Bougherara et al. 2021; Schröter and Mergenthaler 2021; Lapiere et al. 2023, etc.). To minimize design complexity, we focused on six contextually relevant attributes with different attribute levels based on feedback from seminar participants and a stakeholder meeting with a Swedish dairy industry partner at the study design stage. Additionally, we focused on these attributes because they can be clearly understood and meaningfully evaluated by respondents within a choice task and can be actionable through policy programs. The attributes include forage-to-concentrate ratio, social reward, commitment period, type of financial reward, advisory support, and size of financial reward (Table 2).

TABLE 1 | Summary statistics of farmer and farm characteristics ( $N = 348$ ).

Variable	Description	Sample		Population
		Mean	Std. Dev.	Mean
Age	Age of farmer (years)	53.22	11.35	
Female (1/0)	1 if farmer is a female	0.16		
Agric_education (1/0)	1 if farmer has an agricultural education	0.51		
Dairy_experience	Years of dairy farming	24.17	13.28	
Dairy_herd_size	Number of dairy cows	111.60	105.96	110
Grazing_area	Total grazing land area (hectares)	68.03	74.86	
Conventional_prod (1/0)	1 if farmer operates a conventional dairy production system	0.78		0.85
Grass_feed_share	Self-reported proportion of dairy cattle feedstuff derived from forage (%)	66.44	13.49	
Tax_relief (1/0)	1 if farmer received any dairy farm-related tax relief in 2022	0.39		
Price_premium (1/0)	1 if farmer received a consumer price premium for any high-quality dairy product in 2022	0.74		
Advice_feed (1/0)	1 if farmer received advisory support on dairy feeds in 2022	0.54		
Advice_general (1/0)	1 if farmer received advisory support on other aspects of dairy farming in 2022	0.48		
Milk_yield	Energy-corrected milk yield per cow (kg/year)	10436.63	1917.17	9539
Dairy_income_share	Proportion of household's total disposable income (after tax) from dairy farming (%)	78.01	27.34	

TABLE 2 | Attributes and attribute levels.

Attributes	Attribute levels
Forage-to-concentrate ratio	60:40, 65:35, 70:30, 75:25, and 80:20
Social reward	No reward, reward from private sector, reward from public sector
Commitment period	1, 3, 5, 7, and 10 years
Type of financial reward	Direct subsidy payment, consumer price premium, tax relief
Advisory support	No advisory support, advisory support from private sector, advisory support from public sector
Size of financial reward	+1.5, +2.25, +3, +3.75, and +4.5 SEK per litre of milk

Note: 1 Swedish Krona (SEK) to US dollar (USD) and Euro (EUR) was equivalent to approximately 0.093 and 0.086, respectively, during the survey period.

The first attribute, “forage-to-concentrate ratio”, refers to the proportion of forage relative to concentrate in a dairy farm’s feed ration prescribed by the policy scheme. For example, a ratio of 60:40 means that 60% of the lactating dairy cows’ feed by dry weight, is forage, and 40% is concentrate. The second attribute, “social reward”, describes a non-monetary reward offered to dairy farmers in the proposed policy scheme through societal recognition of those farmers who continue to use grass-based feeding even if the scheme ends with an award. An example of social reward used today to recognize high-quality work on dairy farms in Sweden is the Gold Medal award<sup>5</sup>. The third attribute, “commitment period”, refers to the length of commitment to the scheme in years by a dairy farmer. The fourth attribute, “type of financial reward”, describes the type of monetary reward offered

to dairy farmers by the scheme to offset potential additional costs incurred and/or revenue loss associated with applying more grass-based feed rations. The fifth attribute, “advisory support”, captures the provision of free technical advice on applying more grass-based feeding to dairy farmers by the scheme because it is knowledge-intensive. The last attribute, “size of financial reward”, entails the magnitude of monetary reward offered to dairy farmers by the scheme to offset potential additional costs incurred and/or revenue loss associated with applying more grass-based feed rations. For example, +1.5 SEK per litre of milk means that for each litre of milk produced with more grass-based feed rations, you get an extra revenue of 1.5 SEK from the scheme. The levels of the six attributes are designed in relative terms.

We used a Bayesian efficient design based on priors from the pilot survey to minimize the D-error and improve the precision of parameter estimates (Hensher et al. 2015). The design was generated using Ngene software, resulting in 24 paired choice sets randomly blocked into four blocks of six choice sets (D-error = 0.052, A-error = 0.108), and respondents were randomly assigned one of the blocks. Each choice set had two hypothetical options of policy schemes for more grass-based dairy feeding systems (options A and B) and an opt-out (option C)—see a sample of a choice set in the [online supplementary material](#). In the survey, we randomized the order of the choice sets<sup>6</sup>. Also, we combined a cheap talk and an opt-out reminder to better reduce the hypothetical bias inherent in DCE.

### 2.3 | Attitude, Risk and Time Preferences Measurement

We used indicators to measure our latent attitudinal constructs, including attitude towards monetary (direct subsidy payment, tax relief, and consumer price premium) and non-monetary (social reward) policy instruments. This is because the constructs are difficult to measure directly without measurement errors. Drawing on an established theory-driven attitudinal measurement scale (Fishbein and Ajzen 2010) and empirical applications in previous studies (e.g., Sok et al. 2018; Oyinbo and Hansson 2024), we measured the attitudes of interest using two seven-point bipolar items: ranging from unimportant to important and unsatisfying to satisfying (see Table S4).

To minimize time cost and the cognitive burden on respondents, we adopted low-cost and easy-to-implement risk and time preferences measures. Following the seminal paper of Dohmen et al. (2011), we used measurement items that allow farmers to self-assess their risk attitudes on an eleven-point scale, ranging from zero (not willing to take risks at all) to ten (highly willing to take risks), focusing on four domains: agricultural production, agricultural market and prices, agricultural financing, and agri-environmental schemes (see Table S5). Recent studies in DCE have applied this scale (e.g., Bougherara et al. 2021; Lapierre et al. 2023). We used the multiple price list method, which is the most common method of eliciting time preferences (Wuepper et al. 2023). For ease of implementation and given that incentivized and non-incentivized versions of the experiment do not yield different results, as documented by Cohen et al. (2020), we adapted the non-incentivized version applied by Bougherara et al. (2021). In the experiment, farmers are presented with a sequence of five time-discounting tasks (see Table S6), each asking if a farmer would prefer 1000 SEK per dairy cow after one year (smaller but sooner payment)—payment option A or a larger amount after two years (larger but delayed payment)—payment option B, as financial compensation for the farm's provision of ecosystem services<sup>7</sup>. Table S7 shows the distribution of farmers' switching points in the time-discounting tasks.

### 2.4 | Estimation Strategy

Based on the random utility theory (McFadden 1974), we assume that a utility-maximizing dairy farmer faced with fixed options of policy schemes for grass-based feeding systems would choose the

option that offers the highest expected utility level. In our study setting, the overall utility from a given policy scheme option is the sum of the utilities derived from the policy-related attributes of the option (Lancaster 1966). Thus, the overall utility  $U_{ijs}$  that a dairy farmer  $i$  derives from choosing alternative  $j$  of a policy scheme in a choice set  $s$  is given by an indirect identity-based utility function:

$$U_{ijs} = V_{ijs} + \varepsilon_{ijs} = ASC + \sum_{k=1}^K \beta_{ik} x_{ijk} + \varepsilon_{ijs},$$

$$i = 1, \dots, I; j = 1, \dots, J; s = 1, \dots, S \quad (1)$$

where  $V_{ijs}$  is the deterministic component of the utility function,  $\varepsilon_{ijs}$  is the random component of the utility function, which is assumed to be independent and identically distributed (*i.i.d.*).  $x_{ijk}$  is a vector of attributes with associated individual-specific preference parameters  $\beta_{ik}$ , where attribute  $k$  is an element of the vector ( $k=1, \dots, 6$ ). Alternative-specific constant (ASC) represents preferences for the opt-out option and takes a value of one for the opt-out option and zero for the hypothetical options of policy schemes. For ease of interpretation, all categorical variables are dummy-coded.

Building on equation (1), we can adopt a standard or hybrid choice modelling framework (Mariel et al. 2024). However, exploring the role of latent behavioral factors such as attitude, risk and time preferences through a standard choice modelling framework is not trivial. This is because directly incorporating indicators of latent variables in standard choice models raises concerns regarding potential measurement errors and endogeneity bias (Rose et al. 2023; Mariel et al. 2024). Measurement errors are likely to arise as the indicators are functions of the underlying latent constructs and are not the constructs themselves. Similarly, endogeneity may arise, as unobserved factors that are correlated with choices may also be correlated with responses to the indicators (Mariel et al. 2024; Rose et al. 2023). In this sense, we estimate a hybrid LCM, which extends the standard LCM by combining a choice model with a latent variable model (Ben-Akiva et al. 2002). This addresses potential measurement errors and endogeneity bias and allows a better behavioral representation of heterogeneous preferences, as applied in previous studies (e.g., Sok et al. 2018; Rose et al. 2023; Oyinbo and Hansson 2024). The model consists of a latent variable component with measurement and structural functions, estimated using a multiple indicators and multiple causes (MIMIC) model, and a choice component with utility and latent class membership functions, estimated using a latent class model (LCM). The MIMIC model produces the scores for the latent variables, which are included in the LCM, as explanatory variables.

The latent variable (MIMIC) model follows the typical structural equation modelling framework (Rose et al. 2023), where measurement and structural models are simultaneously estimated. The measurement model (confirmatory factor analysis model) tests the relationships between our latent attitudinal variables (attitude towards direct subsidy payment, tax relief, consumer price premium, social reward, and risk attitude) and their indicators. The scores on attitudinal indicators are expressed as the effects of the scores on their corresponding latent constructs:

$$y_{ikl} = \sigma_{kl} \cdot \delta_{ikl} + e_{ikl} \quad i = 1, \dots, I; k = 1, \dots, K; l = 1, \dots, L \quad (2)$$

Where:  $y_{ikl}$  is the score for dairy farmer  $i$  on  $k^{th}$  reflective indicator of the latent variable  $\delta_i$ ,  $\sigma_{kl}$  is the factor loadings, which captures the effect of  $\delta_i$  on  $y_{ikl}$ ,  $e_{ikl}$  is the measurement error associated with a given score and it is assumed to be *i.i.d* and uncorrelated across indicators. The hypothesized latent variables are positively and significantly correlated with all their corresponding indicators (see Table S8). The structural model tests the relationships between farmer and farm characteristics and the latent attitudinal constructs:

$$\delta_{il} = \sum_{n=1}^N \varphi_{ln} z_{in} + \epsilon_{il} \quad i = 1, \dots, I; n = 1, \dots, N; l = 1, \dots, L \quad (3)$$

Where:  $\varphi_{ln}$  is the parameters capturing the effects of the  $n^{th}$  farmer or farm characteristic  $z_n$  on  $\delta_l$ . The error term  $\epsilon_{il}$  is assumed to be normally *i.i.d* and allowed to freely correlate across latent variables. We assessed the convergent and discriminant validity of the latent constructs using average variance extracted (AVE), composite reliability (CR), and squared correlation (SC) among the latent constructs (Hair et al. 2017). Convergent validity, referring to the extent to which indicators of the same construct are strongly related, and discriminant validity, which captures whether constructs are empirically distinct from one another, were supported by AVE, CR, and SC statistics, which meet the recommended thresholds (see results in Table S9). The overall goodness-of-fit of the model is assessed using measures such as chi-square, root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean square residual (SRMR) (Bagozzi and Yi 2012). The estimated model exhibits a good fit (RMSEA = 0.06, CFI = 0.95, SRMR = 0.038,  $\chi^2/df = 2.17$  with  $p$ -value = 0.000).

The hybrid LCM assume that a heterogeneous population of dairy farmers consists of a discrete number of latent preference classes (Hensher et al. 2015). Preferences are assumed to be homogeneous within each latent class  $c$  but heterogeneous across classes. Building on equation (1), the probability of dairy farmer  $i$  choosing alternative  $j$  in a choice set  $s$  is conditional on the farmer's membership of latent class  $c$ . With  $S$  choice sets, the probability of the farmer's sequence of policy scheme choices can be expressed in terms of a logistic distribution:

$$c = \prod_{s=1}^S \frac{\exp(\beta'_c \mathbf{x}_{ijs})}{\sum_{t=1}^J \exp(\beta'_c \mathbf{x}_{its})} \quad (4)$$

where  $\beta'_c$  is the vector of class-specific marginal utilities. Given that class membership is probabilistic, we model the probability that dairy farmer  $i$  belongs to latent class  $c$  using a multinomial logit specification.

The hybrid LCM considers a latent class membership function with class-specific constant terms, observable farmer and farm characteristics, and latent variables:

$$P_{ic} = \frac{\exp(\gamma_{0c} + \gamma'_{1c} \mathbf{z}_i + \gamma'_{2c} \delta_i)}{\sum_{c=1}^C \exp(\gamma_{0c} + \gamma'_{1c} \mathbf{z}_i + \gamma'_{2c} \delta_i)} \quad (5)$$

where  $\delta_i$  is a vector of latent variables of a dairy farmer  $i$  with associated parameters  $\gamma'_{1c}$ . The joint (unconditional) probability of farmer  $i$  making a sequence of policy scheme choices over  $C$

latent classes is the product of (4) and (5):

$$P_i = \sum_{c=1}^C \left[ \frac{\exp(\gamma_{0c} + \gamma'_{1c} \mathbf{z}_i + \gamma'_{2c} \delta_i)}{\sum_{c=1}^C \exp(\gamma_{0c} + \gamma'_{1c} \mathbf{z}_i + \gamma'_{2c} \delta_i)} \right] \left[ \prod_{s=1}^S \frac{\exp(\beta'_c \mathbf{x}_{ijs})}{\sum_{t=1}^J \exp(\beta'_c \mathbf{x}_{its})} \right] \quad (6)$$

The log-likelihood for the sample of  $I$  dairy farmers is as follows:

$$LL = \sum_{i=1}^I \ln P_i = \sum_{i=1}^I \ln \sum_{c=1}^C \left[ \frac{\exp(\gamma_{0c} + \gamma'_{1c} \mathbf{z}_i + \gamma'_{2c} \delta_i)}{\sum_{c=1}^C \exp(\gamma_{0c} + \gamma'_{1c} \mathbf{z}_i + \gamma'_{2c} \delta_i)} \right] \left[ \prod_{s=1}^S \frac{\exp(\beta'_c \mathbf{x}_{ijs})}{\sum_{t=1}^J \exp(\beta'_c \mathbf{x}_{its})} \right]. \quad (7)$$

We estimate models with two to seven latent classes to represent preference heterogeneity in our data sufficiently. The selection of the optimal number of classes is based on statistical fit using Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), as well as model parsimony and behavioral interpretability of estimated parameters. We estimate marginal willingness to accept (WTA) financial compensation (SEK per litre of milk) for different attributes of the proposed policy schemes for more grass-based feeding systems. As a follow-up to the hybrid latent class model estimation, we apply dominance analysis, which is an extension of Shapley value decomposition from Cooperative Game Theory (Luchman 2021), to assess the relative contribution of behavioral drivers versus observable characteristics in the explained heterogeneity in farmers' preferences.

We run a battery of robustness checks. First, we estimate a standard LCM without covariates in the class membership function to test the sensitivity of our hybrid LCM results. This less complex estimation approach assumes that class membership probabilities of the dairy farmers are predicted solely taking into account their sequence of policy scheme choices. Dairy farmers are allocated into latent preference classes where they have the largest membership probabilities. Potential sources of preference heterogeneity are unpacked indirectly through a comparison of a broad set of farm(er) characteristics and attitudinal indicators between latent classes, as applied in previous DCE studies (e.g., Dalemans et al. 2018; Geussens et al. 2019; Oyinbo and Hansson 2024). This allays fears about potential bias in cherry-picking explanatory variables in the membership function and endogeneity concerns associated with the direct inclusion of attitudinal indicators in standard choice models. Second, we estimate a standard LCM with only observable farmer and farm characteristics in the class membership function. In this sense, the sources of preference heterogeneity are unpacked through a narrow set of farmer and farm characteristics, assuming away the role of behavioral factors, and making it less complex than a hybrid LCM. Also, indicators of potentially relevant behavioral factors are not captured in the membership function to avoid potential measurement errors and endogeneity bias. Lastly, we test the robustness of our model to potential attribute inattention bias by re-estimating our hybrid LCM with an additional class, representing a random response class, where estimated parameters of all attributes are constrained

to zero (Malone and Lusk 2018; Lefebvre et al. 2025). All model estimations were performed in Stata.

### 3 | Results

#### 3.1 | Hybrid Latent Class Model Result

Table 3 shows the results of hybrid LCM estimates of marginal utilities for different policy attributes of proposed policy schemes for more grass-based feeding systems in dairy farms. Among the 2088 choices made by the farmers (348 farmers times 6 choice tasks), the opt-out option was chosen 817 times, representing 39% of cases. This suggests that, on average, the proposed policy options of more grass-based feeding schemes account for a larger share of the choices. We selected a model with three preference classes because it provided the best balance between statistical fit, model parsimony, and behavioral interpretability of estimated parameters of models with two to five classes, as models beyond five classes failed to converge (see Table S10). The model shows that the respondents' probability of belonging to preference class one (PC1) is on average 42%, 22% for preference class two (PC2), and 36% for preference class three (PC3). Estimates of the utility function indicate similar preferences for financial compensation, tax relief, and commitment period, and substantial heterogeneity in farmers' preferences for forage-to-concentrate ratio, consumer price premium, social reward, and advisory support between PC1, PC2 and PC3.

Across the preference classes, farmers gain significant utility from policy schemes associated with larger amounts of financial compensation, suggesting that the level of financial payment that can cover the opportunity costs of participating in a more grass-based feeding scheme seems more appealing to farmers. Similarly, farmers obtain positive and significant utility from policy schemes with direct subsidy payments relative to tax relief, as a form of financial compensation. This suggests that dairy farmers in the three classes strongly care about both the amount of financial compensation and the type of financial compensation, especially direct subsidy payments. The latter could be a consequence of farmers' familiarity with direct subsidies in the EU CAP compared with tax relief, indicating a behavioral tendency to resist change or try out alternative modes of compensation. Regarding the use of price premium as a form of financial compensation relative to direct subsidy payment, PC1 derives significant disutility from this mode of payment, PC2 derives significant utility from it, while PC3 is indifferent between the options.

PC1 and PC3 derived significant levels of disutility from the policy schemes offering longer commitment periods. This suggests that longer commitment periods may decrease the likelihood of farmers' enrolment in the scheme. However, PC2 appear indifference to the length of commitment periods. Regarding forage-to-concentrate ratio, PC1 farmers are averse to policy schemes prescribing a higher forage-to-concentrate ratio, which is often expected. This is likely due to potential milk yield reduction and revenue losses associated with high-forage diets, among other factors. However, PC2 farmers derive significant utilities from policy schemes with a higher forage-to-concentrate ratio, which is unexpected. PC1 dislikes policy schemes offering private sector-led implementation of social reward as a form of non-

financial compensation while PC2 and PC3 appear indifferent. Similarly, PC2 dislikes policy schemes offering public sector-led implementation of social reward as a form of non-financial compensation while PC1 and PC3 are indifferent. PC1 farmers obtain significant utilities from policy schemes offering private sector-led implementation of advisory support, while PC2 and PC3 are indifferent. Public sector-led implementation of advisory support is appealing to PC1, but PC2 dislikes it while PC3 is indifferent. Overall, dairy farmers in the three preference classes differ in their responses to schemes with private versus public sector-led implementation of advisory support and social reward policy instruments. The estimated ASC coefficients indicate that PC1 derive positive and significant utility from the proposed policy schemes for more grass-based feeding relative to the opt-out option, PC2 appears indifferent, and PC3 is less open to the proposed policy scheme. Given the observed heterogeneous preferences for the proposed policy schemes for more grass-based feeding systems between the three preference classes, we describe PC1 as the *policy-oriented (PO) farmers*, PC2 as the *policy-indifferent (PI) farmers* and PC3 as the *policy-reluctant (PR) farmers*.

The estimates of the class membership function show that the following observable farmer and farm characteristics: age of farmer, conventional production system, the share of income from the dairy farm, receipt of tax relief and receipt of feed-related advice, and proportion of forage in the dairy farm's feed are statistically significant drivers of the substantial heterogeneous preferences between the three classes. In addition, behavioral drivers, including attitudes towards different modes of compensation, including direct subsidy payment, consumer price premium and social reward, and risk aversion are significantly correlated with the observed heterogeneous differences. Furthermore, the results of our dominance analysis in Table S11, which decomposes the relative contributions of the covariates considered in our model show that observable farm(er) characteristics and behavioral factors contribute 54% and 46%, respectively, to the overall explained heterogeneity in farmers' preferences.

#### 3.2 | Willingness to Accept Financial Compensation

Table 4 reports the estimates of the marginal willingness to accept (WTA) financial compensation for different policy attributes of the proposed grass-based feeding scheme, reflecting the trade-offs farmers are willing to make. Estimates with positive signs indicate how much additional compensation (SEK per litre of milk produced) dairy farmers are willing to accept in return for a decrease in utility associated with a less appealing policy attribute. Similarly, estimates with negative signs indicate how much lower compensation dairy farmers are willing to accept in return for an increase in utility associated with a more appealing policy attribute. Given the range of financial compensation offered to farmers: +1 to +4.5 SEK per litre of milk produced, the WTA estimates show that, on average, farmers in the policy-oriented farmers group require the largest additional compensation level to participate in schemes with a consumer price premium, as the form of financial compensation instead of direct subsidy payment. On the other hand, policy-indifferent farmers are willing to accept the largest reduction in compensation in return for policy

TABLE 3 | Results of hybrid latent class models.

	Hybrid LCM		
	PO	PI	PR
<i>Class probability</i>	0.42	0.22	0.36
<i>Utility function</i>			
ASC	-4.733*** (0.737)	1.471 (0.995)	3.837** (1.680)
Forage-to-concentrate ratio	-0.055*** (0.010)	0.039*** (0.011)	-0.006 (0.022)
Social reward: private	-0.332** (0.149)	0.136 (0.183)	0.181 (0.378)
Social reward: public	0.028 (0.149)	-0.442** (0.184)	0.431 (0.384)
Commitment period	-0.178*** (0.023)	-0.006 (0.024)	-0.138*** (0.052)
Financial reward: price premium	-1.225*** (0.170)	0.458** (0.220)	-0.317 (0.351)
Financial reward: Tax relief	-0.609*** (0.150)	-0.431** (0.183)	-0.861** (0.364)
Advisory support: private	0.282* (0.157)	0.196 (0.189)	0.112 (0.344)
Advisory support: public	0.308* (0.166)	-0.530*** (0.187)	-0.417 (0.392)
Size of financial reward	0.507*** (0.061)	0.396*** (0.076)	0.659*** (0.182)
<i>Class membership function</i>			
_cons	3.687*** (1.339)	-1.868 (1.786)	
Age	-0.023* (0.013)	0.002 (0.016)	
Agric_educ	-0.254 (0.293)	0.051 (0.371)	
Conventional_prod	-0.757* (0.391)	-0.777 (0.507)	
Dairy_herd_size	-0.001 (0.001)	0.000 (0.002)	
Dairy_income_share	-0.003 (0.006)	-0.012* (0.007)	
Grass_feed_share	-0.017 (0.012)	0.036** (0.015)	
Advice_feed	-0.040 (0.290)	0.756* (0.388)	
Tax_relief	0.778** (0.311)	-0.679 (0.430)	

(Continues)

TABLE 3 | (Continued)

	Hybrid LCM		
	PO	PI	PR
<b>Discount_rate</b>	-1.387 (0.977)	0.595 (1.272)	
<b>Attitude_towards_subsidy</b>	0.405** (0.180)	-0.436* (0.229)	
<b>Attitude_towards_tax_relief</b>	-0.085 (0.160)	0.316 (0.200)	
<b>Attitude_towards_price_premium</b>	-0.096 (0.131)	0.391** (0.165)	
<b>Attitude_towards_social_reward</b>	0.001 (0.112)	-0.268* (0.150)	
<b>Risk_aversion</b>	0.021 (0.095)	-0.256** (0.117)	
<b>Number of observations</b>	6264		
<b>Log-likelihood</b>	-1523.019		
<b>AIC</b>	3166.038		
<b>BIC</b>	3570.593		

Note: \*\*\*, \*\*, and \* denote any variable significant at 1%, 5%, and 10% levels, respectively. Standard errors are reported between parentheses. ASC = opt-out option 'I would not participate in any of the policy schemes', Reference levels: social reward = no reward, advisory support = no support, financial reward = direct subsidy payment. PO = policy-oriented, PI = policy-indifferent, PR = policy-reluctant.

TABLE 4 | Estimated marginal willingness to accept (WTA) financial compensation (SEK per litre of milk produced).

	PO Mean	PI Mean	PR Mean
<b>Forage-to-concentrate ratio</b>	0.108 (0.071, 0.155)	-0.100 (-0.179, -0.045)	—
<b>Social reward: private</b>	0.655 (0.043, 1.238)	—	—
<b>Social reward: public</b>	—	1.117 (0.154, 2.210)	—
<b>Commitment period</b>	0.352 (0.262, 0.471)		0.210 (0.061, 0.528)
<b>Financial reward: price premium</b>	2.418 (1.722, 3.325)	-1.156 (-2.546, -0.108)	—
<b>Financial reward: Tax relief</b>	1.202 (0.642, 1.887)	1.089 (0.186, 2.347)	1.307 (0.232, 3.395)
<b>Advisory support: private</b>	-0.556 (-1.210, 0.056)	—	—
<b>Advisory support: public</b>	-0.608 (-1.310, 0.023)	1.337 (0.405, 2.735)	—

Note: WTA values are estimated based on estimated coefficients of the hybrid LCM. 95% confidence intervals are reported between parentheses. Values are not reported for statistically insignificant coefficients, as indicated by "—". PO = policy-oriented, PI = policy-indifferent, PR = policy-reluctant.

schemes with a consumer price premium instead of direct subsidy payment. Compared to the policy-reluctant farmers, the policy-oriented farmers require the largest additional compensation to accept schemes with longer commitment periods. Furthermore, the estimates show that farmers in the policy-reluctant group are willing to accept larger compensation than the policy-oriented and policy-indifferent farmers in return for participating in a scheme with tax relief as the form of financial compensation instead of direct subsidy payment.

### 3.3 | Robustness Checks

Table 5 shows the results of three-class standard LCM without membership function (Model 1), with membership function (Model 2), and a four-class hybrid LCM with a random response class (Model 3). The class probabilities and parameter estimates of three-class standard LCMs are qualitatively similar to the results of our base model—that is, the hybrid LCM. To indirectly unpack the sources of heterogeneous preferences between PO, PI and PR classes based on Model 1, we compare the profiles of dairy farmers by preference classes derived from the model (see Table 6). Except for age of farmer, receipt of feed-related advice, and attitudes towards reward, which are significant in our base model, results in Table 6 show that differences in production system, the share of income from the dairy farm, receipt of tax relief, and proportion of forage in the dairy farm's feed, attitudes towards different modes of compensation and risk aversion behavior underline the observed heterogeneous preferences in line with our base model. Similarly, the drivers of heterogeneous preferences between PO, PI and PR farmers derived from the membership function of Model 2 are consistent with the results from our base model, except for age of farmer and the non-consideration of behavioral factors. These suggest that our results are robust across standard LCMs and the hybrid LCM. Estimates of Model 3 show that the additional class, PC4, where the parameters are constrained to zero has a class probability of 28%, indicating the share of respondents whose choices are likely random, that is, the random response class. This is less than the shares of over 40% reported in other studies (Malone and Lusk 2018; Lefebvre et al. 2025). The inclusion of the random response class partially changes the class probabilities and parameter estimates of some attributes. Compared with our base model, PC1 maps closely to PI farmers while PC2 and PC3 map closely to PO farmers. Overall, the results indicate that the responses of a larger share of respondents are not random, suggesting that base model estimates are less likely affected by inattention bias.

## 4 | Discussion

Our results reveal strong preferences among farmers for policy schemes with larger amounts of financial compensation, indicating that the level of financial payment that can cover the opportunity costs of participating in a more grass-based feeding scheme matters to dairy farmers. This is consistent with previous studies that reported strong farmer preferences for the size of monetary compensations associated with the uptake of more sustainable practices or participation in policy schemes (Christensen et al. 2011; Sok et al. 2018; Šumrada et al. 2022). However, our findings also show that while the size of financial compensation is important, farmers' likelihood of participation in

the policy schemes is driven by both financial and non-financial policy attributes of the schemes. This aligns with the findings of previous studies on farmers' decision-making regarding policy schemes (e.g., Bougherara et al. 2021; Canessa et al. 2023; Lapierre et al. 2023). Notably, we find three distinct groups of dairy farmers with different preference patterns.

The first group, *policy-oriented farmers*, is characterized by farmers who are generally very strongly open to the proposed policy schemes and are more interested in schemes with a direct subsidy payment type and shorter commitment period. In addition, they have a general preference for the presence of advisory support, regardless of whether it would come from the private or public sector. This aligns with the findings of other studies on the role of advisory support in increasing the likelihood of farmer participation in policy schemes (Lapierre et al. 2023). While receptive to private sector-led advisory support, they are uninterested in private sector-led social reward. The resistance to private sector-led social reward is in contrast with the findings of previous studies indicating that societal recognition of farmers can motivate pro-environmental behavior (Banerjee et al. 2021; Howley and Ocean 2021). Yet in line with Trenholm et al. (2017), the lack of interest in societal recognition could be due to farmers' concerns about their privacy.

The second group, *policy-indifferent farmers*, is generally indifferent to enrolling in the proposed policy schemes and considers schemes with a higher forage-to-concentrate ratio and consumer price premium payment type potentially more attractive. The openness to the use of price premium as a form of financial compensation relative to direct subsidy payment partly supports the findings of a few studies that reported a positive preference for consumer price premium payment type but not relative to direct subsidy payment (Danne and Musshoff 2017; Schreiner and Hess 2017; Schröter and Mergenthaler 2021). In addition, *policy-indifferent farmers* consider schemes without public sector-led implementation of social reward and advisory support potentially more appealing, indicating that they are sensitive to private or public sector-led implementation of these instruments. Regarding advisory support, this is consistent with Wuepper et al. (2021) who reported that Swiss fruit growers' pest management choices vary depending on receipt of advice from private or public extension.

The third group, *policy-reluctant farmers*, is generally very weakly open to the proposed policy schemes and considers schemes with a direct subsidy payment type and with a shorter commitment period more appealing. Plausible explanations for reluctance to participate in the scheme could be due to uncertainty associated with policy changes and future payments, forage quality and quantity, and the extent of milk yield reduction. This could also be a consequence of higher opportunity costs of participation, especially for more intensively managed farms (Schaub et al. 2023) and lock-in effects from previous investments in feeding systems. Furthermore, this could also be a consequence of misperception about losing their farm autonomy from enrolling in such schemes, especially with longer commitment periods (Dessart et al. 2019). The negative role of irreversible long-term commitments in disincentivizing participation in the policy scheme aligns with the findings of other studies (e.g., Christensen et al. 2011; Banerjee et al. 2021).

TABLE 5 | Results of latent class models showing robustness checks.

	Standard LCM without and with class membership function										Hybrid LCM with a random response class		
	Model 1					Model 2					Model 3		
	PO	PI	PR	PO	PI	PR	PO	PI	PR	PC1	PC2	PC3	Random response class
<b>Class probability</b>	0.40	0.24	0.36	0.42	0.23	0.35	0.18	0.22	0.32	0.28			
<b>Utility function</b>													
<b>ASC</b>	-4.255*** (0.872)	0.584 (1.052)	3.715** (1.698)	-4.301*** (0.767)	0.774 (1.082)	3.882** (1.689)	1.978* (1.093)	-2.647*** (1.001)	-5.850*** (0.966)	4.325*** (0.367)			
<b>Forage-to-concentrate ratio</b>	-0.049*** (0.012)	0.029** (0.011)	-0.009 (0.022)	-0.050*** (0.010)	0.033*** (0.012)	-0.007 (0.022)	0.042*** (0.012)	-0.046*** (0.013)	-0.038*** (0.010)				
<b>Social reward: private</b>	-0.386** (0.158)	0.129 (0.189)	0.154 (0.379)	-0.359** (0.148)	0.110 (0.183)	0.152 (0.383)	0.251 (0.217)	-0.419* (0.220)	-0.092 (0.154)				
<b>Social reward: public</b>	0.038 (0.157)	-0.385** (0.191)	0.482 (0.379)	0.062 (0.148)	-0.420** (0.189)	0.427 (0.387)	-0.447** (0.211)	-0.006 (0.211)	0.074 (0.156)				
<b>Commitment period</b>	-0.176*** (0.025)	-0.014 (0.026)	-0.129** (0.052)	-0.173*** (0.023)	-0.013 (0.024)	-0.127** (0.054)	0.013 (0.028)	-0.200*** (0.034)	-0.142*** (0.026)				
<b>Financial reward: price premium</b>	-1.271*** (0.197)	0.467* (0.268)	-0.388 (0.356)	-1.218*** (0.175)	0.455** (0.231)	-0.333 (0.362)	0.716*** (0.266)	-1.026*** (0.222)	-1.073*** (0.219)				
<b>Financial reward: Tax relief</b>	-0.578*** (0.163)	-0.414** (0.188)	-0.852** (0.354)	-0.613*** (0.150)	-0.368** (0.179)	-0.822** (0.369)	-0.416* (0.220)	-1.057*** (0.210)	-0.523*** (0.177)				
<b>Advisory support: private</b>	0.315* (0.165)	0.169 (0.184)	0.002 (0.340)	0.277* (0.156)	0.213 (0.184)	0.025 (0.350)	0.241 (0.283)	0.135 (0.226)	0.337 (0.226)				
<b>Advisory support: public</b>	0.439** (0.193)	-0.666*** (0.226)	-0.520 (0.374)	0.353** (0.178)	-0.583*** (0.185)	-0.490 (0.388)	-0.693*** (0.232)	0.147 (0.234)	0.198 (0.199)				

(Continues)

TABLE 5 | (Continued)

	Standard LCM without and with class membership function			Hybrid LCM with a random response class						
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3				
<b>Size of financial reward</b>	0.504 *** (0.068)	0.405 *** (0.075)	0.699 *** (0.189)	0.484 *** (0.063)	0.409 *** (0.074)	0.665 *** (0.189)	0.362 *** (0.090)	0.530 *** (0.098)	0.522 *** (0.065)	—
<b>Class membership function</b>										
<b>_cons</b>	0.123 (0.168)	-0.395* (0.222)		3.130** (1.285)	-1.067 (1.589)		-1.255 (2.085)	6.426*** (1.768)	4.834*** (1.630)	
<b>Age</b>				-0.015 (0.013)	-0.014 (0.015)		-0.023* (0.013)	-0.050*** (0.018)	-0.031** (0.016)	
<b>Agric_educ</b>				-0.247 (0.286)	0.164 (0.358)		-0.254 (0.293)	-0.170 (0.365)	-0.581* (0.344)	
<b>Conventional_prod</b>				-1.058*** (0.372)	-0.539 (0.442)		-0.757* (0.391)	-0.782 (0.497)	-0.781* (0.438)	
<b>Dairy_herd_size</b>				-0.001 (0.001)	0.001 (0.001)		-0.001 (0.001)	-0.002 (0.002)	-0.001 (0.002)	
<b>Dairy_income_share</b>				-0.003 (0.005)	-0.012* (0.006)		-0.003 (0.006)	-0.001 (0.007)	-0.006 (0.007)	
<b>Grass_feed_share</b>				-0.017 (0.012)	0.033** (0.014)		-0.017 (0.012)	-0.045*** (0.015)	-0.020 (0.014)	
<b>Advice_feed</b>				-0.076 (0.282)	0.726** (0.353)		-0.040 (0.290)	0.119 (0.373)	0.135 (0.337)	
<b>Tax_relief</b>				0.713** (0.288)	-0.545 (0.430)		0.778** (0.311)	0.707* (0.394)	0.843** (0.366)	
<b>Discount_rate</b>							-1.387 (0.977)	-1.781 (1.262)	-2.411** (1.137)	

(Continues)

TABLE 5 | (Continued)

	Standard LCM without and with class membership function		Hybrid LCM with a random response class	
	Model 1	Model 2	Model 2	Model 3
<b>Attitude_towards_subsidy</b>			0.405** (0.180)	0.366* (0.217)
<b>Attitude_towards_tax_relief</b>			-0.085 (0.160)	-0.206 (0.191)
<b>Attitude_towards_price_premium</b>			-0.096 (0.131)	-0.055 (0.167)
<b>Attitude_towards_social_reward</b>			0.001 (0.112)	-0.037 (0.145)
<b>Risk_aversion</b>			0.021 (0.095)	0.269** (0.122)
<b>Number of observations</b>	6264	6264	6264	6264
<b>Log-likelihood</b>	-1561.161	-1540.234	-1461.891	-1461.891
<b>AIC</b>	3186.323	3176.468	3075.782	3075.782
<b>BIC</b>	3402.085	3500.112	3588.218	3588.218

Note: \*\*\*, \*\*, and \* denote any variable significant at 1%, 5%, and 10% levels, respectively. Standard errors are reported between parentheses. ASC = opt-out option "I would not participate in any of the policy schemes"; Reference levels: social reward = no reward, advisory support = no support, financial reward = direct subsidy payment. PO = policy-oriented, PI = policy-indifferent, PR = policy-reluctant, PC = Preference class.

TABLE 6 | Profile of dairy farmers by preference classes.

	PO	PI	PR	PO =PR	PI =PR		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
<i>Farmer and farm characteristics</i>							
Age	52.29	11.51	53.21	11.80	54.28	10.84	
Female	0.19		0.13		0.15		
Agric_education	0.51		0.53		0.51		
Dairy_experience	23.07	13.21	23.75	13.71	25.71	13.02	
Conventional_system	0.70		0.79		0.87		***
Grazing_area	65.21	72.91	71.05	63.55	69.17	84.12	
Grass_feed_share	64.98	13.39	69.45	11.00	66.07	14.85	*
Dairy_herd_size ('0)	10.6	7.51	11.62	8.78	11.49	14.20	
Milk_yield ('000)	10.42	1.6	10.26	1.81	10.57	1.84	
Diary_income_share	76.65	26.77	74.94	30.68	81.65	25.31	*
Tax_relief	0.48		0.31		0.34		**
Premium_price	0.74		0.74		0.76		
Advice_feed	0.52		0.61		0.51		
Advice_general	0.53		0.52		0.40		** *
Discount_rate	0.25	0.16	0.24	0.16	0.26	0.15	
<i>Farm location</i>							
Southern_Sweden	0.21		0.17		0.12		*
Central_Sweden	0.62		0.64		0.52		
Northern_Sweden	0.27		0.19		0.26		
<i>Attitudinal indicators</i>							
<i>Attitude towards direct subsidy payment</i>							
Att_dsp1	5.20	1.54	4.69	1.98	4.52	1.93	***
Att_dsp2	5.00	1.60	4.71	1.99	4.47	1.95	**
<i>Attitude towards tax relief</i>							
Att_tr1	4.99	1.51	4.90	1.79	4.48	1.98	**
Att_tr2	4.73	1.62	4.87	1.82	4.39	1.96	*
<i>Attitude towards consumer price premium</i>							
Att_cpp1	4.93	1.49	5.23	1.79	4.67	1.86	**
Att_cpp2	4.94	1.43	5.21	1.86	4.55	1.88	* **
<i>Attitude towards social reward</i>							
Att_sr1	4.95	1.77	4.57	1.88	4.58	2.01	
Att_sr1	4.99	1.74	4.54	1.88	4.70	1.94	
<i>Risk attitude</i>							
Att_risk1	4.96	2.09	4.30	2.54	5.20	2.23	***
Att_risk2	5.21	2.10	4.69	2.26	5.45	2.23	**
Att_risk3	5.38	2.35	4.70	2.52	5.33	2.64	*
Att_risk4	5.05	2.262	5.06	2.33	6.14	2.73	*** **

(Continues)

TABLE 6 | (Continued)

	PO	PI	PR	PO = PR	PI = PR		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
<b>Risk_aversion</b>	5.15	1.84	4.69	1.92	5.53	2.01	***
<b>N</b>							

Note: Tests of equality of means between PO and PR and PI and PR using two-sided t-test and Chi-squared test for continuous and categorical variables, respectively. The tests are based on the preference class probability of Model 1 in Table 5. \*\*\*, \*\*, and \* denote significant differences at 1%, 5%, and 10% levels respectively. Att\_dsp1 and Att\_dsp2 are the indicators of direct subsidy payment described in Table S4. Att\_tr1 and Att\_tr2 are the indicators of tax relief described in Table S4. Att\_cpp1 and Att\_cpp2 are the indicators of consumer price premium described in Table S4. Att\_sr1 and Att\_sr2 are the indicators of social reward described in Table S4. Att\_risk1, Att\_risk2, Att\_risk3 and Att\_risk4 are the indicators of risk attitude described in Table S5. PO = policy-oriented, PI = policy-indifferent, PR = policy-reluctant.

Our findings show that the observed heterogeneous preferences between the segment of farmers characterized as policy-oriented, policy-indifferent and policy-reluctant farmers are associated with differences in some farmer and farm characteristics, as well as behavioral factors. Interestingly, more intensive farms characterized by a conventional production system and lower forage-based feeds are less likely to participate in the proposed scheme. This aligns with the findings of empirical studies (e.g., Canessa et al. 2023), which reported that more intensive farms who are often more profit-oriented are less likely to participate in agri-environmental schemes, partly due to higher opportunity costs of participation compared with less intensive farms. While time preference is theoretically relevant in settings with intertemporal choices, rather surprisingly, we do not find supportive evidence in the context of policy schemes for more grass-based feeding systems. A possible explanation for the negligible role of time preference could be that most farmers are accustomed to intertemporal decisions inherent in dairy farms due to the considerable time lag for dairy cows to generate returns. Risk aversion is negatively associated with farmer participation in schemes with a higher forage-to-concentrate ratio, as reflected by policy-indifferent farmers. This is plausible because transitioning to more grass-based feeding systems may be associated with uncertainty in quantity and quality of forage, uncertainty in milk yield and financial compensations to offset the costs associated with the forage-based feeds or revenue loss due to possible milk yield reduction. This is in line with Lapierre et al. (2023), who posit that one of the factors that discourages farmers from enrolling in policy schemes is the uncertainty of the costs and benefits associated with the adoption of sustainable agri-environmental practices. Attitudes towards direct subsidy payment and consumer price premium underline the strong preference for direct subsidy payment and consumer price premium as modes of financial compensation by policy-oriented and policy-indifferent farmers, respectively. This is expected as individual attitudes towards a behavior often shape preferences, as documented in other studies (e.g., Sok et al. 2018; Mariel and Arata 2022; Oyibo and Hansson 2024).

## 5 | Conclusions and implications

This study provides novel insights into how dairy farmers in Sweden respond to policy schemes for more grass-based feeding with direct subsidy payment versus alternative modes of financial compensation and to private versus public sector-

led implementation of policy instruments, and into preference heterogeneity driven by underlying economic and behavioral drivers.

Our findings show substantial heterogeneity in farmers' preferences for policy attributes of more grass-based feeding schemes. We find three distinct groups of farmers: policy-oriented, policy-indifferent and policy-reluctant farmers who differ in their likelihood of participating in the schemes and exhibit heterogeneous preferences for schemes with private versus public sector-led implementation of social reward and advisory support, and direct subsidy payment versus consumer price premium and tax relief. Also, our findings demonstrate that beyond differences in some farmer and farm characteristics, behavioral factors, including farmer attitudes and risk aversion explain the observed heterogeneous preferences between the policy-oriented, policy-indifferent and policy-reluctant farmers. This lends credence to the consideration of insights from behavioral economics to better explain farmer decisions regarding policy schemes (Palm-Forster and Messer 2021; Schaub et al. 2023). This typifies the complexities of farmers' decision-making processes, as they are often motivated by multiple (and often conflicting) production goals, which inform their actions, and such actions are often not perfectly rational from a neoclassical economic perspective (Dessart et al. 2019). In this regard, relying solely on observable farmer and farm characteristics would be insufficient in explaining farmers' decisions regarding participation in voluntary policy schemes.

We provide some important policy implications towards efficient design of policy schemes for more grass-based feeding systems in settings where the transition to such feeding systems is challenging for farmers without appropriate policy incentives. First, our findings imply that dairy farmers do not solely require higher levels of financial compensation but can accept lesser financial compensation if certain non-financial policy attributes are incorporated into schemes for grass-based feeding systems. This suggests that besides the level of payment, strong attention to non-monetary policy attributes, such as public and private sector-led implementation of advisory supports and alternative payment via consumer price premium can improve cost-effective scheme design and the likelihood of farmers' participation in the scheme. This aligns with the critical role of scheme design from the reviews by Börner et al. (2017) and Schulze et al. (2024). Second, given that a longer commitment period disincentivize the likelihood of farmer participation in the proposed schemes,

the design of the schemes should strongly consider a flexible commitment period that allows easy exit from the scheme when necessary ‘an opt-out option’ or a shorter commitment period that allows re-enrolment to the scheme. This can allay concerns about the perceived loss of farm autonomy and other behavioral biases that underlie farmers’ aversion to schemes with longer-term commitment periods.

Third, drawing on our findings regarding the substantial heterogeneous preferences exhibited by three groups of dairy farmers, a one-size-fits-all voluntary policy scheme would likely be less attractive and cost-effective compared to schemes targeted at the three groups. In this regard, targeting heterogeneous farmer groups with policy schemes for more grass-based feeding systems that take into account their preferences is more likely to improve the attractiveness and cost-effectiveness of the schemes. In particular, our results highlight the need for a combination of public and private incentive schemes and that a focus on either subsidy payments or consumer price premiums will be insufficient to encourage uptake among heterogeneous farmer groups. However, the practical implementation of such targeted policy schemes would require further research and policy engagement in light of the potential implementation challenges, such as monitoring and unintended farmer responses. It also requires a deeper understanding of how public and private sector-led initiatives to encourage more sustainable production practices can coincide. Fourth, our findings indicate that both public and private sector-led implementation of social rewards are unappealing policy attributes that should not currently be considered in the portfolio of non-financial policy instruments for more grass-based feeding schemes. Similarly, the inclusion of tax relief as an alternative to direct subsidy payment in grass-based feeding schemes would not improve farmer participation in the scheme and may even be a disincentive to some farmers. However, we note that these implications are context-specific and may not apply to other EU country contexts, given that behavioral responses to policy instruments for more sustainable practices can vary by context, as discussed by Dessart et al. (2019). Future studies can explore the role of social reward and tax relief in other EU countries and in the context of other sustainable practices. Finally, reflecting on the role of attitudes, risk and time preferences in explaining heterogeneous preferences, our findings imply that incentivizing farmers’ participation in more grass-based feeding schemes would require complementary interventions targeted at inducing positive attitudes towards policy instruments in the schemes and managing the potential risks of transitioning to more grass-based feeding systems. This would require some evaluations to inform the design of such interventions. While time preference did not shape farmers’ choices in our study context, this may not apply to other contexts. Future studies can explore the role of time preferences in other contexts, and behavioral factors not considered here.

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disclose that AI was not used in generating any content of the paper. The authors take full responsibility for the content of the paper.

### Conflicts of Interest

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

### Endnotes

- <sup>1</sup>In Swedish setting where agro-climatic conditions do not favor outdoor grazing all-year round, *more grass-based feeding systems* entail a shift towards more forage-based diets, especially grass-clover silage in indoor feeding and extended outdoor grazing during the grazing season with lower grain-based concentrates. For the latter, farmers can voluntarily extend dairy cow grazing hours and days beyond the mandatory minimum of 6 hours daily across all regions and 60 days during the period from May 1–October 1 in Northern Sweden, 90 days during the period April 1–October 31 in Central Sweden, and 120 days during the period 1 April–31 October in Southern Sweden, as stipulated by Swedish animal welfare legislation (Swedish Board of Agriculture 2024a).
- <sup>2</sup>Dairy farming in Sweden has become increasingly intensive over the years, as reflected by a downward trend in the total number of dairy farms and dairy cows, and an upward trend in the size of dairy farms and milk yield per cow (see Figure S1 in the online supplementary material).
- <sup>3</sup>The formal consent statement is in the first page of the questionnaire, which is available in the [online supplementary material](#).
- <sup>4</sup>Attrition rate was computed as the number of farmers who dropped out (624) divided by the total number of farmers who started but did not complete the survey or completed the survey (972) multiplied by 100.
- <sup>5</sup>This was included in the survey to help farmers better understand social reward in the hypothetical scheme.
- <sup>6</sup>However, we did not randomize the positions of alternatives in the choice tasks. Given the unlabelled nature of our DCE, the baseline model specification includes a single alternative-specific constant capturing the average utility of opting into any of the policy alternatives relative to the opt-out. To allay concerns about potential bias due to non-randomization of the positions of alternatives in the choice tasks, we estimate conditional logit models with single and separate alternative-specific constants for policy options A and B (see results in Table S3). Results are qualitatively similar, indicating robustness to potential bias from non-randomizing the order of the policy options in the in the choice tasks.
- <sup>7</sup>To improve the choice realism of the experiment, we use 1000 SEK as the payment option A, which is equivalent to the cattle support that Swedish dairy farmers received in 2023 for each cattle older than one year.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section.

**Supplementary Table S1:** Comparison of the study sample and the target population. **Supplementary Table S2:** Comparison of the attritors and non-attritors. **Supplementary Table S3:** Results of Conditional Logit models. **Supplementary Table S4:** Descriptive statistics of the indicators of farmers' attitudes towards different forms of compensation<sup>1</sup> (%) – N = 348. **Supplementary Table S5:** Descriptive statistics of farmers' risk attitudes in different domains<sup>1</sup> (%) – N = 348. **Supplementary Table S6:** Multiple price list for discount rate elicitation using a one-year payoff time horizon **Supplementary Table S7:** Frequency distribution of farmers' switching points **Supplementary Table S8:** Results of MIMIC model. **Supplementary Table S9:** Convergent and discriminant validity of the

latent constructs **Supplementary Table S10:** Criteria for the selection of optimal number of preference classes **Supplementary Table S11:** Standardized dominance statistics **Supplementary Figure S1:** Dairy intensification trend in Sweden (Swedish Board of Agriculture, 2024) **Supplementary Figure S2:** Spatial distribution of registered dairy farms in Sweden by county