Journal of Cleaner Production 389 (2023) 136026

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

A payment scheme for the ecosystem services of mountain grasslands embedded in dairy products

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ARTICLE INFO

Handling Editor: Cecilia Maria Villas Bôas de Almeida

Keywords:
Mountain pastures
Sustainable farming
Discrete choice experiment
Local policy

ABSTRACT

Mountain pastures and meadows have been disappearing at a steady pace from the Italian Alpine and Apennine regions for the last century. Livestock farms and pastoral activities have traditionally contributed to preserving them, but they are facing increasingly adverse socio-economic and climatic trends The aim of the paper is to explore the economic feasibility of a payment scheme for grassland-based ecosystem services embedded into locally produced dairy products that can compensate farmers' effort and increase their profitability. Using the method of discrete choice experiments, we estimate Italian consumers' willingness to pay for a set of selected attributes of mountain cheese associated with provisioning, cultural, and existence ecosystem services. Our results indicate that consumers would be willing to pay cheese 4€/kg to 6€/kg more for each increase in the level of ecosystemic attributes, thus supporting the introduction of a payment scheme as a local and scalable policy intervention.

1. Introduction

Mountain grasslands, pastures, and open woodlands are important sources of ecosystem services, stores of biodiversity and endemic species, and have long been acknowledged as cultural landscapes (Garbarino et al., 2011). In the Alpine region and the Italian Apennine, grasslands and open woodlands are semi-natural environments, shaped by centuries of traditional land use and maintenance patterns involving small-scale and low-intensity pastoral activities. Family-run livestock farms, based on high-altitude seasonal pastures and low-input hay cultivation and mowing, have typically determined both the extent of those ecosystems and the persistence of the flow of their ecosystem services, contributing to the formation of diversified landscape features with high conservation value and ecological performances. In doing so, mountain livestock farms also allowed the formation of ecosystem-based local identities and cultural values and ensured the supply of traditional high-value and high-quality local products, thus supporting the sustainable development of local communities.

Since the 1950s, however, a multitude of socioeconomic, cultural, and climatic factors (MacDonald et al., 2000; Strijker, 2005; Tasser et al., 2007; Vitali et al., 2018) has determined a progressive abandonment and marginalization of alpine spaces. Alongside the rural population exodus resulting from the booming of urban industries, the gradual mechanization and intensification of livestock farming in fertile lowland areas have led to a continuous decline in mountain farming revenues (Faccioni et al., 2019; Mazzocchi and Sali, 2019). The remoteness, the adverse morphological conditions and physical constraints, and the shortened grazing season not only increase production costs and limit competitiveness but, combined with limited possibilities of capital investments, extremely risk-averse practices, and limited human capital prevent the adoption of technological innovation and the possibility of operating on profitable premium markets, further hindering the economic sustainability of high-altitude farming. These developments have been exacerbated by the increasingly acute consequences of climate change, such as rising temperatures and extreme weather events.

The direct consequence of the decrease in the number of traditional livestock farms, or high nature value farms (Baldock et al., 1998), is the gradual reversion of grazed areas into shrublands and secondary forests (Tattoni et al., 2021). Even if "rewilding" could be considered a positive phenomenon in the short term (Marini, 2007; Pereira and Navarro, 2015), ecological assessments showed that a decline in habitat heterogeneity and biodiversity across mountain landscapes is prevailing, mainly due to the low biodiversity value of the invading species (Marini

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https://doi.org/10.1016/j.jclepro.2023.136026
Received 11 October 2022; Received in revised form 10 January 2023; Accepted 11 January 2023
Available online 20 January 2023
0959-6526/

et al., 2007; Peco et al., 2005; Pereira and Navarro, 2015). Correspondingly, forest cover in Italy is estimated to have increased by 40% in the years between 1936 and 1985 and by a further 20% in the three subsequent decades (Garbarino et al., 2020). Further consequences of mountain land abandonment are cultural and socio-economic: a loss of mountain heritage and historical traditions, the depopulation of small high-altitude villages, and the underprovision of ecosystem functions and services (Benayas et al., 2007).

In the EU, since the Agenda 2000 (European Commission, 1997), the Common Agricultural Policy (CAP) and the regional rural development programs (RDPs) have included subsidies to compensate small mountain farmers for living in remote and extreme conditions and sustain their economic viability. However, their current design has proven ineffective in preventing under-grazing (Buckwell et al., 2017; Guyomard et al., 2021) and the size of subsidies has been limited compared to the value of the ecosystem services that each farming activity supplies (Reed et al., 2014; Sturaro et al., 2013). In the absence of specific policy interventions, the current use and maintenance of mountain pastures and meadows are unlikely to be sustained in the future, with inevitable consequences in terms of further land abandonment and diffusion of closed landscapes (Battaglini et al., 2014; European Commission, 2018).

Along these lines, this study aims to investigate the feasibility of introducing a site-specific hybrid Coasian/Pigouvian payment scheme for ecosystem services (PES). The compensation to mountain livestock farms for their active effort of preserving the pastures and meadows would come from a price premium on their products proportional to the value that consumers attribute to the ecosystem services they embed. The scheme could represent an incentive towards more ecologically proactive farming practices, improve the profitability of small mountain farms, and, eventually, increase the chances of sustained maintenance of grasslands in the future.

The feasibility of the scheme depends, on the one hand, on the actual willingness-to-pay (WTP) of consumers for the extra direct and indirect benefits associated with mountain ecosystem services embedded in products and, on the other, on the development of a public certification and labeling standard that delivers candid and credible information on the environmental content of the products offered.

The main focus of the paper is to test the plausibility of the first requisite by using a discrete choice experiment (DCE) to estimate consumers' WTP for the services provided by mountain pastures and other grassland-based ecosystems that are embedded into mountain cheese, a product that is highly representative of the pastoral activities of farms in the Alps. Although cheese is a market good, we choose a stated preference method because, at present, information on the value of the various ecosystem services contained in commercialized mountain cheeses is neither available nor can be derived from final prices. Connecting WTP to specific and well-defined ecosystem services using a DCE ensures that the preferences being elicited are not conflated with anything unrelated to ecosystems, a strict requirement of a transparent PES scheme.

This article, therefore, belongs to the broader empirical literature dedicated to payment schemes for ecosystem services but intends to contribute, specifically, to the definition of a novel cross-regional/regional strategy based on the idea of co-management of mountain pastures where mountain farms are recognized and compensated as active custodians of alpine ecosystems and biodiversity. The policy mechanism proposed allows an improved approach to the complex challenges of small mountain farming and aims at the development of an economic and ecologically virtuous circle.

Results show that Italian consumers are willing to pay up to 6€/kg more at each increase (from low to average to high) in the level of ecosystem services embedded in mountain cheese. Specifically, the attributes associated with ecosystem services that were valued the most include animals foraged from high-quality, self-produced mountain grass; production based on agropastoral traditions; production that contributes to preserving mountain pastures. The estimated price premium can be considered sufficient to support the long-term survival of mountain livestock farming, given the existing empirical evidence. Sturaro et al. (2013) found that, in the province of Trento, Italy, traditional mountain livestock farms selling milk on PDO markets at a 30%–40% premium compared to the baseline market price have showcased long-term economic sustainability without significant changes in the production process.

The main policy implication of our findings is that a payment scheme as the one described could be adopted in the Italian Alpine and Apennine regions, but its success is dependent on the involvement of the public authorities in the development of a credible certification and labeling system that effectively communicates to consumers the actual level of ecosystem-related attributes in mountain products.

The remainder of the paper is organized as follows: Section 2 provides the framework for the payment scheme; Section 3 illustrates the methodology; Section 4 describes the data and the results; Section 5 concludes.

2. The payment scheme

PES schemes are a widespread policy instrument (Salzman et al., 2018; Wunder et al., 2008) used to achieve sustainable ecosystem management and pursue environmental preservation, whose use has been encouraged by the EU 2020 Biodiversity Strategy (European Commission, 2011) and that is going to play an important role in many EU parties' strategic plans foreseen by the latest CAP 2023–27 reform.

An extensive conceptual and empirical literature has developed over the years to examine alternative incentive program designs (Duke et al., 2014; Engel et al., 2008; Wu et al., 1995) and estimate farmers' willingness to accept the compensatory payment using discrete choice experiments (Christensen et al., 2011; Cooper, 2003; Cooper and Keim, 1996; Lynch and Lovell, 2003). Examples of existing and successful PES schemes for dairy farming are those developed by Vittel in eastern France to address the risk of nitrate contamination caused by agricultural intensification in the aquifer (Perrot-Maitre, 2006) and the community-based PES program on the prevention of farmland abandonment in the mountainous areas of Japan (Shoyama et al., 2021).

It is relatively common for ecosystem services to be jointly produced. When that is the case, a payment scheme can bundle different services, so that payments cover the full bundle, or stack them so that different beneficiaries pay for different services. However, when there is complementarity in production and the marginal cost of producing the complementary services is zero, it is common practice to "piggy-back" them, so that one or few services are paid for through the scheme and the co-generated services are supplied free of charge (Wunder and Wertz-Kanounnikoff, 2009).

Together with public payments (CAP subsidies, in Europe, or a fully Pigouvian payment scheme), PES can be used by policymakers to support mountain livestock farms. It is generally assumed that public payments are more appropriate to support the production of ecosystem services that mostly display the characteristics of public goods and that excludability and rivalry in consumption tend to justify market-based solutions. Along with this standard criterion, though, other factors may influence the viability of a PES compared to CAP subsidies. Firstly, they ensure the proportionality between payments and the size of the supplied flow of ecosystem services. Secondly, they are scale appropriate: subsidies may be more appropriate for large-scale interventions, whereas a PES scheme may be more manageable for interventions at a regional or local level and could be quicker to finalize. Thirdly, PES schemes have greater adaptability to changes in the context (e.g. changes in preferences associated with ecosystem services). Lastly, they provide a stronger commitment/incentive toward the use of sustainable practices.

The PES scheme considered in this paper is closely related to those discussed in the literature: we consider the case of an endangered ecosystem that is privately managed and needs to be safeguarded. However, for that to be possible, the scheme must first preserve a class of ecosystem managers from being pushed out of the market by their inability to internalize the externalities they produce. Thus, our case differs from the standard in two main aspects.

The first aspect is that production is already oriented toward the preservation of ecosystems but is not financially sustainable. As mentioned, traditional mountain farms are typically small family businesses, with minimal contribution of hired work and small borrowed capital, facing high costs due to a hostile production environment. Thus, our PES scheme should be designed to financially support these small-scale businesses and prevent their disappearance, stimulate their use of green practices, and encourage newcomers in the market of mountain farming.

The second aspect is that the considered ecosystems supply a range of potential flows of services. In addition to providing forage, mountain grasslands are linked to the historical pastoral and transhumance culture, contribute to carbon sequestration and water purification, are habitats for pollinators and wildlife, contribute to various recreational activities, and, *per se*, have an existence and bequest value. We argue that some of these services can be reasonably embedded into mountain products and, in the form of credence attributes (Darby and Karni, 1973; Nelson, 1970), provide utility to consumers. For instance, some cultural services can be benefited indirectly by consuming mountain products: eating cheese made from historical pastoral craft production is a way to experience mountain traditions.

While this paper focuses on the estimation of the WTP for mountain grassland ecosystem services, another fundamental requirement for the development of the PES scheme proposed is that the environmental content and quality of the goods produced are credibly signaled to the potential purchasers. Currently, most small livestock farms are prevented from joining renowned certification schemes (e.g., BIO, PDO) because they are conceived for larger productions or are too expensive. Thus, the design of our PES scheme is based on the development of a credible certification standard and labeling able to certify the presence of ecosystem services in the products offered.

To sum up, the PES proposed is based on the joint contribution of three actors. Farmers should prove the use of sustainable practices in their pastoral production activities; public authorities should develop certification and labeling standards; consumers should be willing to pay a price premium for the additional environmental benefits contained in mountain goods once made aware of them.

3. Methodology

To estimate consumers' WTP concerning a set of ecosystem services, we use a DCE (Train, 2003) directed to a representative sample of the Italian population. The only other paper that explicitly estimates the monetary value of a set of mountain grassland ecosystem services in Italy using a DCE is the one by Faccioni et al. (2019).[1] Using alternative policy scenarios, they show that a sample of inhabitants from the Nord-East regions of Italy has a positive WTP for four ecosystem services provided by Alpine agrosystems, namely conservation of agricultural landscapes, maintenance of biodiversity, provision of quality local food products linked to the territory, and water quality. As policy implications, they recommend the development of PES schemes to sustain farmers and preserve alpine ecosystems.

Differently from their application, in our experimental setting ecosystem services represent production inputs and, at the same time, attributes of the dairy product in a Lancaster's type characteristics model of consumer preferences (Lancaster, 1966). Attribute levels together with price are used to model consumers' choices in front of alternative product scenarios.

The development of the DCE survey instrument exploits the network of actors and multidisciplinary experts of two ongoing Interreg (France-Italy) projects concerning biodiversity and mountain livestock herding in the Maritime Alps and the Northern Apennines.[2] The experimental design includes three web-based surveys: a pilot survey on a multiregional subset of the population, a main national survey, and a secondary survey presented to a smaller bi-regional sample. The secondary survey was designed to clarify if, and to what degree, localism affects the consumer preferences elicited in the main survey. Data collection was contracted out to a management polling firm and was administered to their online panel between January and March 2021.

3.1. Product and attributes selection

Mountain cow milk cheese was selected as the focus of the DCE as it is well-known among Italian consumers, and it is produced by most Alpine and Apennine farmers. Consultations with experts in pastoral practices, biologists, and farmers, and four focus groups with stakeholders (i.e., personnel of protected areas, local and regional government representatives, local touristic and environmental associations, farmers, and consumer associations) were conducive to the identification of the attributes to be included in the DCE.

The final selection had to comply with some key criteria. Increasing levels of the selected attributes had to be: (1) plausibly capable of generating additional WTP and (2) functionally related to the conservation of mountain pasture and meadow ecosystems (assuming sustainable production processes). The latter condition is better understood with the following example: compared to the baseline of generic animal feed bought on the market, the larger the share of provisioning service sustainably extracted from mountain pastures and meadows to feed the animals at present, the greater the chance of having non-decreasing flows of future services and thus a non-decreasing net present value of the ecosystem because extracting the service implies preventing reafforestation. Similarly, the greater the quality of the service because of the botanical composition of the sward from which the service is extracted, the better the protection is given to the net present value of the ecosystem because maintenance is directed to more valuable ecosystems. For other services, like carbon sequestration or water flow regulation, this may not be true, and the criterion is therefore not met. Even after considering the two criteria, a long list of ecosystem services had acceptable characteristics, and ultimately, the selection of just three reflects practical concerns about experimental design and modeling.

It is worth mentioning that approximately 50 face-to-face interviews were made with mountain farmers to identify the key elements of their production activity and to assess their level of environmental awareness. It emerged that the mountain farmers sampled prioritize animal welfare, are generally mindful of their positive and negative environmental impact, are conscious of the ecosystemic content of their product but are not aware of its financial worth, and typically lack an entrepreneurial mindset. Farmers' attitudes toward environmental conservation are key factors in the implementation of PES schemes (Cranford and Mourato, 2011; Kosoy et al., 2007).

An infographic was carefully studied, with the collaboration of graphic designers, to allow a clear visual understanding of the various attributes in the online format. The following four attributes connected with cheese production methods were selected: animal feed (*Forage*); link to tradition (*Heritage*); ecosystem preservation (*Ecosystem*); ethical approach to animal welfare (*Ethics*). To estimate the WTP for these attributes, a price corresponding to a 200 g retail pack of the selected cheese was included as a further attribute. The relative levels and

[1] It should be mentioned that Huber and Finger (2020) use a meta-analysis approach to estimate the WTP for cultural services from grassland ecosystems. They show that an increase in mountain grassland landscaper due to a less-intensive land use in mountain regions is associated with a WTP of €53.

[2] See https://www.interreg-alcotra.eu/it/decouvrir-alcotra/les-projets-finances/biodivalp for the Maritime Alps project and http://interreg-maritime.eu/web/cambio-via for the Northern Apennines project.

infographic are presented in Fig. 1.

The attribute *Forage* is used as a proxy of the level of pasture and meadow provisioning service embedded in the product: the environmental content is lowest when forage is purchased from third parties, while is highest when it is self-produced within the boundaries of a (mountain) protected site, a relatively common occurrence across the regions covered in this study that implies a much stricter control on the production process. From the focus groups also emerged that animal breed is typically associated with the organoleptic properties of cheese and that, thus, consumers may associate a livestock varied diet with a tastier and healthier cheese. *Heritage* is introduced to communicate the embedded cultural ecosystem value of the cheese product and its link to historical local traditions of high-altitude pastoralism and transhumance. *Ecosystem* is considered to value consumers' WTP for a cheese produced using sustainable practices that ensure the preservation of the mountain pasture ecosystems. Finally, animal welfare (*Ethics*) is used to capture different degrees of ethical farming, with a baseline where legal animal health requirements are met.

The first three attributes in Fig. 1 are directly related to the ecosystem services identified in the Common International Classification of Ecosystem Services (Haines-Young and Potschin, 2018). The fourth attribute is not related to ecosystem services but has become a more common selling point for products and can therefore be used as a familiar reference item to compare the relative intensity of preferences.

3.2. Development of the survey instrument

The survey instrument consists of three sections. The first section includes standard socio-economic questions and a question on the frequency of cheese consumption. The second section introduces the DCE (Louviere et al., 2000) with 8 choice tasks composed of two alternatives and a no-buy/delayed-choice option: two pieces of cheese described by the five attributes and a no-buy option "neither A nor B". The third section consists of questions on consumption habits, i.e., where respondents make their food purchases and how often, interest in reading food labels and in buying organic food, and interest in local labels from protected areas. An early version of the survey was administered to a representative sample of North-West Italy consisting of 200 respondents. At that stage, all four environmental attributes in Table 1 had three levels and some of them had slightly different wording. Choice tasks for the pilot survey were assembled as a random sample of 200x8 combinations from the full factorial design of the experiment and were randomly assigned (without replacement) to respondents. The results were used to improve the survey instrument, with wording that suggested a "longer" scale for *Forage* and *Ethics* and one less level for *Heritage*.

3.3. Experimental design

Following the adjustments, to reduce the choice situations to a manageable number per respondent, we generated a blocked Bayesian a-efficient design with priors obtained from the pilot survey. The design was optimized for multinomial logit models with fixed parameters We accounted for "model uncertainty" by averaging the optimization process (Rose et al., 2009) over two possible model specifications, one that included only the main effects and one that included both the main and the two-way effects. While the two models did not cover the full variety of potentially relevant specifications, they provided a reasonable compromise between simpler optimization and greater flexibility. The efficient design was constrained to have no cases of strict dominance between alternatives and was blocked so that 1134 respondents were presented with 8 choice occasions each. The design was generated using the modified Fedorov algorithm in the commercial software ngene. For the secondary survey, we generated a simpler design, optimizing only for the main effects model and we accounted for having labeled alternatives by assuming a distinct constant parameter for each alternative. Once more, the design was blocked so that 166 respondents were presented with 8 choice occasions each.

3.4. Data collection

We tested the web version of the survey prepared by the contractor before each stage of the survey campaign to check its conformance with the required specifications. The survey was administered with the C.A.W.I. (Computer-Assisted Web Interviewing) method using the commercial software idsurvey. The risk of randomness in responses to surveys involving pre-recruited online panels is a known issue and is associated with response times (Börger, 2016). To tackle this, quality control procedures of the contractor were set to reassign questionnaires to other respondents with similar demographic characteristics if the answer to any single question was too quick or too slow depending on the characteristics of the question.[3] An open-ended question was introduced as an additional control check for possible fraudulent responses.

3.5. Econometric approach

The standard econometric framework to analyze DCE data when preference heterogeneity among different decision-makers cannot be excluded is represented by mixed logit models (Train, 2003). In that framework, the utility that a decision-maker n obtains at time t from choosing an alternative j among J available alternatives is given by

$$U_{njt} = \alpha_{(n)j} + \beta_n x_{njt} + \gamma w_{njt} + \delta_j z_{nt} + \varepsilon_{njt} \tag{1}$$

where $\alpha_{(n)j}$ is a fixed or random alternative-specific constant, the vector of alternative-specific variables x_{njt} has random coefficients β_n varying over decision-makers in the population, the vector of alternative-specific variables w_{njt} has fixed coefficients γ and the vector z_{nt} of case-specific variables (that is, constant over the alternatives faced by the same decision-maker) has fixed alternative-specific coefficients δ_j. The random term ε_{njt} follows a type I extreme value distribution (see Appendix A for more details). All the discrete choice models used in this paper are based on equation (1) but differ on important specification details. For simplicity, we make exclusive use of specifications where α is non-random. Furthermore, the estimates based on data from the main survey are referred to choices between unlabelled alternatives. When that is the case, we assume that decision-makers have no intrinsic preference over unlabelled alternatives except as a consequence of their observed characteristics. Therefore, all choice models for unlabelled alternatives are constrained to have $\alpha_{Cheese\ A} = \alpha_{Cheese\ B}$.

We generally estimate the coefficients for the attributes *Forage, Heritage, Ecosystem,* and *Ethics* as correlated, random, and normally distributed. Such specification appears *a priori* as the most plausible and is confirmed as opportune by the empirical results. A well-known issue of random specifications for "cost" parameters is that, when used to estimate willingness-to-pay, they imply ratios of two randomly distributed terms, so that the resulting estimates are potentially affected by heavily skewed distributions and undefined moments (Johnstone et al., 2017). We address the issue concerning our *price* attribute on two levels. First, we compare two specifications in which *Price* has either a fixed coefficient or a random and lognormally distributed coefficient. Finding no decisive difference in the results, we adopt the specification with the fixed coefficient, which is closer to the model used for designing the experiment.[4] However, to add a further degree of caution, when presenting our results in terms of WTP, we compare those from models with a fixed coefficient for *Price* with those obtained from an equivalent model estimated in WTP space (Scarpa et al., 2008; Train and Weeks,

[3] s for choice occasions two to eight.

[4] The software used for experimental design is currently unable to estimate efficient designs for models in willingness-to-pay space.

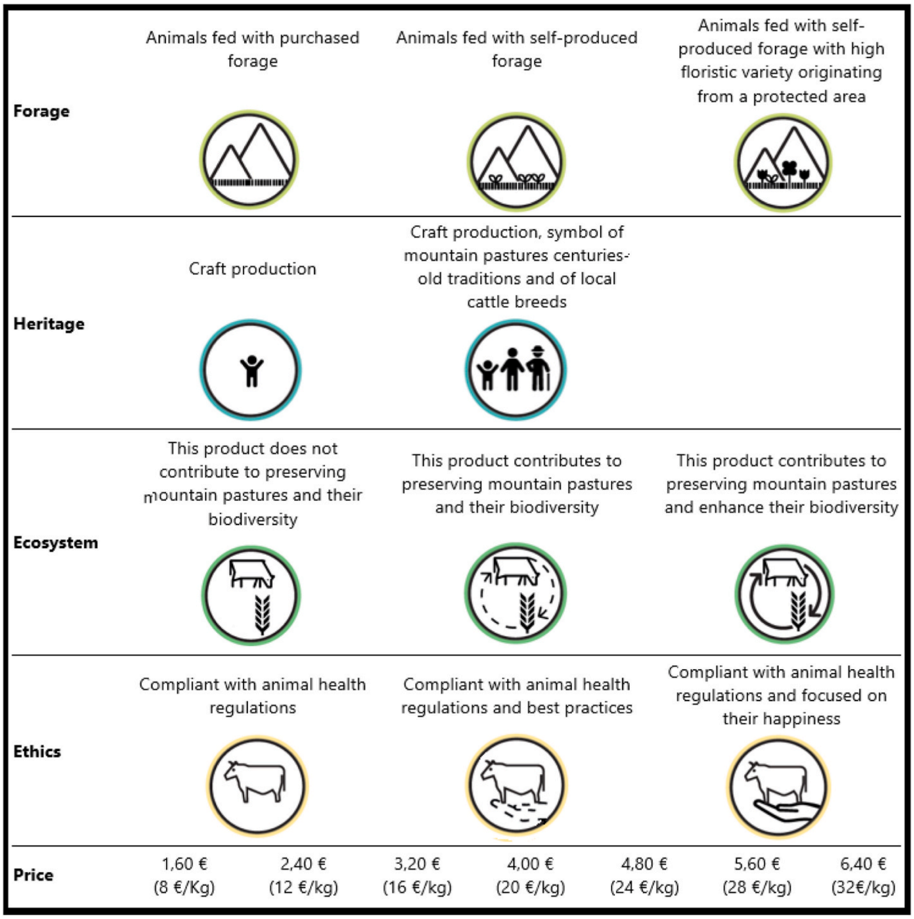

Fig. 1. Attributes and levels of the choice experiment.

2005).

4. Results and discussion

4.1. Descriptive statistics from the supporting questions

The survey instruments described earlier filter out consumers that reported no meaningful consumption of cheese. Out of 1134 respondents in the main survey, 942 are occasional or frequent consumers of cheese (83%). Table B1 in Appendix B reports the descriptive statistics for such a group. The demographic portion of the results is mostly in line with a representative sample of Italians aged 18–74, with a balance between males and females, more populated age groups between 50 and 60 years of age, a large share of couples (around 70%) and about 51% of the respondents not living with children. People not holding at least a high school degree (less than 20%) is under-represented in the sample, as official statistics for people aged 20–64 indicate that the share of Italians without a high school degree is over 26%.[5]

Regarding the stated consumption behavior of the respondents concerning food and cheese, frequent consumers of cheese are over 80% of the sample. The preferred retail outlets for food, in general, are supermarkets, followed by local shops, farmers' markets, and farm shops at the production site, whereas the role of e-commerce is minimal. Furthermore, most respondents stated a frequent or systematic habit of reading labels, whereas PDO and organic food, as well as ethical food products, are bought sometimes or frequently. Finally, consumers appear to have a strong interest in food products explicitly labeled as produced within the boundaries of a protected area and in full respect of the environment.

4.2. Estimates of model coefficients, standard deviations, and correlations

Table 1 reports the coefficient estimates of four specifications of the mixed logit model introduced earlier. In Model 1, the coefficient for *Price* is assumed constant, the coefficients for the other attributes are random and normally distributed and no case-specific variables are included. The estimated values for all five attribute coefficients are significant at $p < 0.01$ and exhibit the expected sign. The marginal rate of substitution between *Forage* and *Ecosystem* is approximately 1, whereas a unit increase in *Heritage* is equivalent to an increase of about 0.65 in *Forage* and a unit increase in *Ethics* is only worth a 0.3 increase in *Forage*. The constant term is positive, indicating that respondents have a much larger preference for buying either Cheese A or Cheese B than for delaying consumption. In Model 2 the coefficient for *Price* is random and lognormally distributed. All positive coefficients increase from Model 1 to Model 2, but the change in the coefficient for *Price* is larger (if not large enough to produce substantive consequences) and the model fit is somewhat better. Based on this result, we assume that estimating a constant price coefficient is probably acceptable but implies a non-trivial loss of accuracy: as anticipated, in the remainder of the paper we will not provide WTP estimates based on a constant price term without putting them side-by-side with an estimate from an equivalent model in WTP space.

Model 3 introduces a few selected two-way interactions. There is some evidence that increasing levels of *Ecosystem* may have a reduced effect when *Price* is high, but this finding is not particularly robust to different specifications of the model.

[5] See http://dati.istat.it/(year 2019).

Table 1
Coefficients for base models.

	1 - MXL correlated Gaussian coef.		2 - MXL correlated lognormal price		3 - MXL correlated two-way effects		4 - MXL correlated Gaussian coef., ASC	
Price	−0.315	***	−0.466	***	−0.250	***	−0.314	***
	(0.01)		(0.03)		(0.05)		(0.01)	
Forage	0.403	***	0.449	***	0.403	***	0.399	***
	(0.03)		(0.03)		(0.03)		(0.03)	
Heritage	0.263	***	0.318	***	0.264	***	0.258	***
	(0.04)		(0.05)		(0.04)		(0.04)	
Ecosystem	0.392	***	0.440	***	0.581	***	0.390	***
	(0.03)		(0.03)		(0.06)		(0.03)	
Ethics	0.120	***	0.138	***	−0.034		0.113	***
	(0.03)		(0.03)		(0.06)		(0.03)	
Ecosystem*Price					−0.047	***		
					(0.01)			
Ethics*Price					0.022	*		
					(0.01)			
ASC								
Either cheese	2.551	***	3.283	***	2.309	***	−0.697	
	(0.16)		(0.19)		(0.24)		(0.82)	
Education							−0.277	**
							(0.12)	
Localshop							0.350	***
							(0.07)	
Supermarket							0.352	***
							(0.11)	
PDO							0.560	***
							(0.12)	
N	942		942		942		942	
ll	−5850.3867		−5654.1828		−5842.3678		−5815.906	
aic	11732.77		11342.37		11720.74		11671.81	
Bic	11861.19		11478.81		11845.43		11810.36	

Note: Model 1 is a mixed logit model of main effects only, with correlated, Gaussian-distributed random coefficients, with an alternative-specific constant for either cheese vs. neither. 2 is a mixed logit model of main effects only, with correlated, Gaussian-distributed random coefficients and a lognormally distributed coefficient for price, with an alternative-specific constant for either cheese vs. neither. 3 is a mixed logit model of main and selected two-way effects with correlated, Gaussian-distributed random coefficients, with an alternative-specific constant for either cheese vs. neither. 4 is a mixed logit model of main effects only with correlated, Gaussian-distributed random coefficients, with an alternative-specific constant for either cheese vs. neither and selected alternative-specific variables. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors in parentheses.

Model 4 is the second-best in terms of goodness of fit, a result that comes from introducing a selected group of case-specific variables[6] that are particularly effective in explaining the variability of the constant term. The baseline scenario represented by the constant (mountain cheese from an artisanal production process) is more attractive to frequent users of local shops and supermarkets and frequent buyers of PDO products. Interestingly, an increasing level of education reduces the acceptance of our baseline scenario. The effect is smaller than that of the retail outlets and about half that of *PDO* but still sizeable and suggests that a class of more sophisticated consumers may be inclined to restrict their consumption choices to food with better or different environmental qualities than our baseline scenario.

Table 2 reports, for the same four models, the estimates on the standard deviations of the random parameters and those on their correlations. In all models, the standard deviations are statistically significant, and their value is relatively consistent across models. Thus, it is reasonable to assume (continuous) heterogeneity in tastes over the attributes and an overall degree of dispersion of tastes around the mean that is not overly affected by the model specification. Modest positive correlations are found between *Forage* and *Heritage* and between *Forage* and *Ethics* across all models. A stronger dependence is estimated between *Heritage* and *Ethics*, reflecting a behavioral pattern worth exploring with further research. Possibly consumers assume that local breeds and traditional productions imply greater animal welfare. The literature on the issue has sometimes suggested, instead, a negative relation between traditional values and concern for animal welfare (Cembalo et al., 2016).

The weak negative correlation between Ecosystem and Ethics in Model 4 is the lone instance in which the former attribute's coefficient is correlated with other coefficients. As such, the two attributes with a more altruistic form of relationship with utility could perhaps be negatively dependent, but it is quite certain that *Ecosystem* reflects a dimension of consumer preferences that is distinct from all other environmental dimensions we have considered.

4.3. Robustness

Results are found robust to different econometric specifications. Even comparing the results of the pilot survey and the main survey, the parameter estimates for attributes that do not change in scale are remarkably consistent: the marginal rate of substitution between *Heritage* and *Ecosystem* is 0.68 (pilot model) or 0.66 (Model 4) and the marginal rates of substitution between both attributes and price are, respectively, 0.84 or 0.82 and 1.219 or 1.224.

An important robustness check when the same decision-maker is presented with repeated choices consists in looking for evidence of learning (the experiment is better understood after the first few choice occasions) or preference formation and fatigue (Johnstone et al., 2017). In Table D1 in Appendix D, Model 5 has the same specification (although without allowing correlation) as Model 1 but is estimated only on data from the first and second choice occasion presented to each respondent, whereas Model 6 uses the same specification on data from the next-to-last and last choice occasion presented to each respondent. The results for Models 5–6 confirm the robustness of the estimates: the only coefficient changing notably in the two models is the constant, suggesting it is the only parameter that could be affected and that should

[6] Some case-specific variables were not included as they consistently prevented model convergence across different specifications.

Table 2
Standard deviations and correlations for the random parameters of base models.

	1		2		3		4	
Normal								
sd(Forage)	0.472	***	0.454	***	0.468	***	0.454	***
	(0.04)		(0.04)		(0.04)		(0.04)	
sd(Heritage)	0.631	***	0.695	***	0.633	***	0.608	***
	(0.06)		(0.06)		(0.06)		(0.06)	
sd(Ecosystem)	0.615	***	0.542	***	0.618	***	0.592	***
	(0.04)		(0.05)		(0.04)		(0.04)	
sd(Ethics)	0.287	***	0.307	***	0.284	***	0.307	***
	(0.04)		(0.05)		(0.04)		(0.04)	
Lognormal								
sd(Price)			0.701	***				
			(0.10)					
Correlations								
corr(Forage, Heritage)	0.330	***	0.358	***	0.331	***	0.280	**
	(0.12)		(0.12)		(0.12)		(0.12)	
corr(Forage, Ecosystem)	0.110		−0.032		0.125		0.038	
	(0.10)		(0.12)		(0.10)		(0.10)	
corr(Forage, Ethics)	0.365	**	0.452	***	0.351	**	0.363	**
	(0.15)		(0.15)		(0.16)		(0.14)	
corr(Heritage, Ecosystem)	−0.026		−0.046		−0.019		−0.115	
	(0.11)		(0.11)		(0.10)		(0.11)	
corr(Heritage, Ethics)	0.556	***	0.709	***	0.543	***	0.598	***
	(0.16)		(0.17)		(0.17)		(0.16)	
corr(Ecosystem, Ethics)	−0.188		−0.226		−0.188		−0.264	**
	(0.13)		(0.15)		(0.13)		(0.12)	

*p < 0.1; **p < 0.05; ***p < 0.01. Standard errors in parentheses.

therefore be seen as potentially less reliable (perhaps overestimated).

4.4. Willingness-to-pay

Table 3 reports WTP estimates based on Model 4 (on the right side of the table) and those obtained with an equivalent model in WTP space (left side of the table). It must be stressed that the range of validity of the estimates cannot be automatically extended outside the vector of prices that were tested in the survey. In other words, although inviting, predictions of WTP for products with multiple attribute improvements over the baseline level should not be trusted if the implied price exceeds 32 Euros per Kg. We observe that Model 4 systematically provides lower estimates for the attributes: in the case of *Heritage* and *Ecosystem*, WTP is about two-thirds of that obtained with Model 7; the estimates for *Forage* and *Ethics* are closer and the constant terms vary from being very close to considerably different. Importantly, though, the differences found in the estimated values for the attributes are not large enough to lead to a different interpretation of the results.

Table 3
Estimated WTP for a unit increase in the attributes.

	7 - MXL correlated Gaussian coef. in WTP-space		WTP from Model 4 MXL correlated Gaussian coef.	
			WTP	[95% Confidence intervals]
Forage	1.588 (0.11)	***	1.268	[1.061 1.475]
Heritage	1.260 (0.15)	***	0.822	[0.542 1.102]
Ecosystem	1.918 (0.13)	***	1.239	[1.042 1.436]
Ethics	0.503 (0.09)	***	0.361	[0.190 0.531]
ASC				
Either cheese	−4.779 (0.90)	***	−2.216	[-7.328 2.896]
Education	−1.492 (0.15)	***	−0.881	[-1.654–0.107]
Localshop	1.347 (0.14)	***	1.114	[0.638 1.589]
Supermarket	1.888 (0.16)	***	1.119	[0.452 1.786]
PDO	2.025 (0.36)	***	1.778	[1.006 2.550]
N	942		942	

Note: Model 7 is a mixed logit model with the same specification of Model 4 but estimated in WTP space and, consequently, coefficients should be interpreted as WTP values [the coefficient of price is omitted]. In the columns under Model 4 are reported WTP values based on the coefficients of Model 4 and their corresponding 95% confidence intervals. *p < 0.1; **p < 0.05; ***p < 0.01. Standard errors in parentheses.

Even the lowest estimates from Table 3 indicate that consumers would trade, on average, between 0.8 and 1.2 Euros per unit of cheese in exchange for a unit increase in *Forage*, *Heritage,* or *Ecosystem*, corresponding to an increase of 4–6 Euros per Kg. We previously mentioned a 30%–40% price premium over environmentally unqualified products as a plausible threshold for the economic sustainability of small dairy producers in mountain areas. If that were the case, a two-level improvement in *Forage* or *Ecosystem* (or a combination of the two) would be sufficient for the economic sustainability of products currently sold without environmental qualifications at less than 30 Euros per Kg. A unit increase in animal welfare, in comparison, would only result in an increase of 1.5 Euros per Kg in WTP, and improvements in this attribute, at least in the scale we tested, would not be enough to reach the sustainability threshold starting from any meaningful market price.[7]

Fig. 2 displays (on the left) marginal predictions from Model 4 at different price levels when Cheese B (dashed line and light grey 95% confidence interval) is a low-cost and environmentally unqualified product, that is when *Forage*, *Heritage,* and *Ecosystem* are fixed at the lowest value and the unit price is fixed at 1.6 Euros (8 Euros per Kg). The predicted preferences for the low-cost alternative overcome those for an environmentally qualified product only beyond a unit price of 4 Euros (20 Euros per Kg). On the right, the same low-cost Cheese B is compared to Cheese A (solid line and dark grey 95% confidence interval) which has *Forage*, *Heritage,* and *Ecosystem* fixed at the highest level. In this case, the predicted preferences for Cheese B do not overcome those for Cheese A until the latter is priced at around 35 Euros per Kg.

Fig. 3 represents, together, both the predictions concerning Cheese A from Fig. 2. The solid line and dark grey confidence interval correspond to the preferences for Cheese A in the left panel of Fig. 2 and the dashed line and light grey correspond to the preferences for Cheese A in the right panel. Fixing *Forage*, *Heritage,* and *Ecosystem* at the highest level is shown to shift the predicted preferences up by more than 15 percentage points at price levels above 3 Euros per unit (15 Euros per Kg).

[7] Appendix C illustrates how results change if we consider geographically defined subsample of the population.

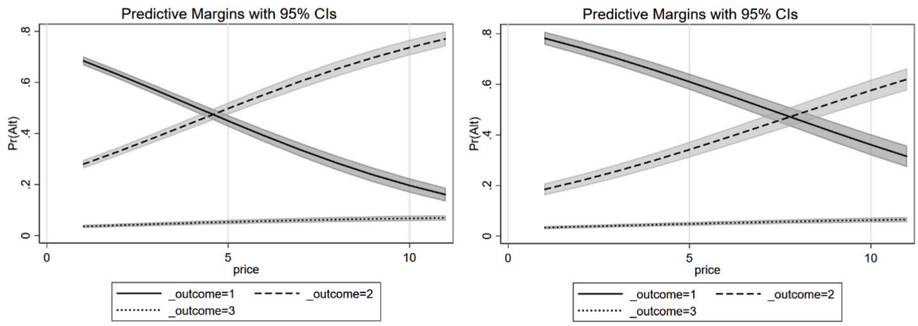

Fig. 2. (left) predicted preference for Cheese A (solid line) and 95% confidence interval (dark grey) at increasing price levels (x-axis) if alternatives consist in Cheese B (dashed line, 95% confidence interval in light grey) with all attributes related to ecosystem services set to the lowest level and price set to 1.6, and the opt-out choice (dotted line, 95% confidence interval in grey) which corresponds to all attributes a price set to 0. (right) the same comparison except for all ES-related attributes of Cheese A being set to the highest level.

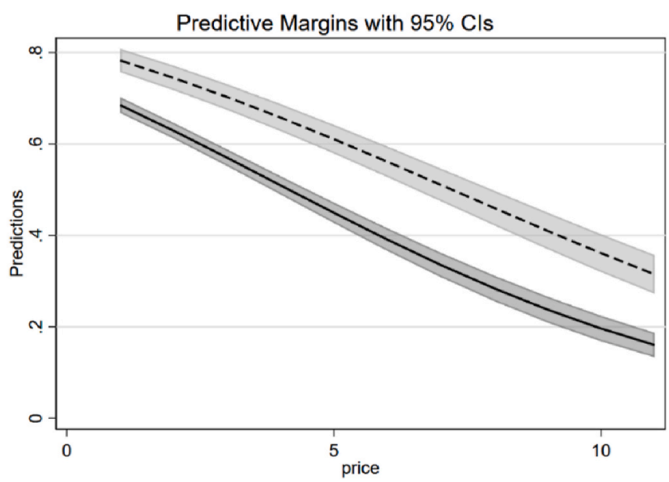

Fig. 3. predicted preference for Cheese A (solid line, 95% confidence interval in dark grey) and predicted preference for Cheese A if all ES-related attributes are at the top level (dashed line, 95% confidence interval in light grey).

Table 4
Model in WTP-space for the bi-regional sample or restricted to regional samples.

	11 - MXL Gaussian coef. in WTP-space		11 - MXL Gaussian coef. in WTP-space, only Liguria		11 - MXL Gaussian coef. in WTP-space,only Lombardy	
Forage	1.020	**	1.540	***	0.563	**
	(0.26)		(0.29)		(0.24)	
Heritage	2.073	**	1.433		2.178	**
	(0.84)		(1.32)		(0.86)	
Ecosystem	2.493	***	1.003		2.838	***
	(0.63)		(0.69)		(0.71)	
heritage*ecosystem	−0.927	**	−0.378		−1.156	***
	(0.38)		(0.53)		(0.41)	
Ethics	0.018		0.758	**	−0.178	
	(0.23)		(0.34)		(0.22)	
ASC						
Formaggetta (Lig)	5.456	***	5.181	***	5.507	***
	(1.51)		(1.94)		(1.83)	
Formaggella (Lom)	5.940	***	3.538	*	7.240	***
	(1.53)		(1.89)		(1.90)	
N	138		65		73	

Note: *p < 0.1; **p < 0.05; ***p < 0.01. Standard errors in parentheses.

4.5. Labelled experiment

Table E.1 and Table E2 in Appendix E report the coefficient estimates and the of WTP for three models fitted on data from the secondary survey, involving an about equal share of people living in the regions of Lombardy and Liguria. As discussed earlier, the models are applied to a labeled experiment and the labels refer to two comparable local products (one for each region) that have limited distribution (and notoriety) outside of their production area. The sample is much smaller than in the main survey, which may account for the relatively large standard errors for the estimates concerning the weaker parameters.

The estimates for *Price, Fodder,* and *Ecosystem* are remarkably close to those from Model 1 and the estimate for *Ethics* is also comparable (although not statistically significant). The coefficient for *Heritage* represents the main difference from the estimates of Model 1 because it is much smaller (and not statistically different from 0). The symbolic and identity-related ecosystem service embedded in the product could, in principle, have a different appeal for consumers depending on the place of production, thus justifying the non-significant coefficient. The overall consequences of having specific product labels are limited and do not change the substantive conclusions coming from the main survey.

A more detailed look into the implications of localistic preferences is given in the models in Table 4. Model 11 is compared to the estimates obtained on the subsamples of respondents from Liguria and respondents from Lombardy. The number of observations is small but even so, there are hints that the previously observed geographic variability in preferences persists and is possibly magnified after introducing labels. Interestingly, label values (the alternative-specific constants) are shifted “up” in Lombardy, so that while each population displays greater WTP for the local product, the sample from Lombardy acknowledges the Ligurian product about the same value that Ligurians themselves are willing-to-pay. This may reflect, among other things, differences in average income between the two regions.

5. Conclusions and policy implications

This paper explores the economic feasibility of a payment scheme for some ecosystem services of mountain pastures and meadows of the Italian Alps and Apennines that are potentially embedded in dairy products. The scheme is highly interesting from a policy standpoint because mountain pastures, grasslands, and open woodlands are precious but increasingly endangered stores of biodiversity, and their decline is strictly connected with the decline of traditional livestock farming.

The idea behind the PES proposed is that mountain livestock farms, as ecosystem managers, would receive a payment for preserving pasture ecosystems by consumers buying their products. A fundamental prerequisite for the feasibility of such a scheme is the existence of positive consumers’ WTP for the extra benefits they can gain from consuming a product embedding mountain ecosystem services. In particular, three services are identified as potentially relevant to the scheme: provisioning of mountain-grown forage that improves the quality of dairy products; symbolic and heritage aspects connected with pastures and meadows, that may enter the product and be “remotely” consumed to experience the local identity through food; finally, existence and bequest services, that could reasonably enter the product, given that production (if sustainably managed) is the main driver of conservation.

A DCE conducted through a survey on a large representative sample of Italian consumers of cheese was used to test the WTP of consumers for the three services along with animal welfare. Lacking a high-resolution and detailed breakdown of costs of intensive and mountain/extensive livestock farms, a tentative reference level for long-term economic sustainability was set by looking at how literature described the success of the traditional farming model in an area of the Italian Alps where small producers systematically sold milk for PDO productions for a 30%–40% premium on average.

Results indicate a substantial effect of all three types of ecosystem services that we tested on consumer choices. The provisioning service and the existence/bequest service were found to be potentially worth around 12 Euros per Kg of cheese each as the environmental content of the product increases from the bottom level to the top level. The cultural service was valued at around 4 Euros per Kg and, for the sake of comparison, animal welfare at farms was valued at around 3 Euros per Kg. The results were found to be robust across several model specifications and consistent across space (with non-substantive local variations). Marginal predictions suggest that most consumers would choose a low-cost, environmentally unqualified cheese rather than one equipped with average environmental quality when the latter costs more than 20€/Kg. A cheese with top environmental qualities is preferred to the low-cost one up to a price of around 35€/Kg. These results are consistent with observed prices: small PDO mountain cheese productions with bland certifications concerning production and environmental impact are sold at around 20€/Kg, and premium products can be priced at or above 35€/Kg.

A secondary investigation conducted with a labeled discrete choice experiment involving a smaller sample from Liguria and Lombardy and a local cheese from each region confirmed the results, suggesting that localistic preferences affect WTP pay for the local label and for the environmental content of the product enough to encourage targeted marketing efforts but not enough to significantly hinder the chances of achieving economic sustainability because of localization.

In sum, this paper provides evidence in support of the development of a PES scheme to improve the profitability of mountain livestock farms and, in turn, safeguard mountain pasture and meadow ecosystems and the flow of services they produce. Consumers appear to understand and attach a significant value to the content of ecosystem services in mountain cheese when such content is expressed in plain language and is made salient in the choice process.

This has direct managerial policy implications. Implementing the scheme requires a credible system of certification and labeling for mountain livestock farms based on the quantification of ecosystem services. Such a system would be in stark contrast with the plethora of existing certifications of food products focused on some specific dimension of sustainability that are ultimately incapable of conveying information on the net effects that the production process has on ecosystems and their contributions to humankind. Also, the system requires public intervention, as small producers in less-favored areas are structurally lacking the human capital and the resources to acquire equivalent certifications on the market. Although challenging, this certification system is favored by the push towards mapping and assessing ecosystems and their services at the European level and by the steps made in that direction already (Bouwma et al., 2018; Maes et al., 2012), which means that the required information for a national (or supra-national) policy is not unattainable.

There is also some argument in favor of the possibility of coordinated local and scalable market-based payment schemes. They imply a smaller burden than a traditional subsidy (covering transaction costs but not production costs) and are much more likely to stay within the powers of local governments without encroaching on the exclusive powers of national and supra-national institutions. It is also worth noting that, because almost a quarter of the alpine region belongs to protected areas and many producers operate within their boundaries or close enough, the management bodies of the protected areas have substantial knowledge about how each producer operates and could therefore provide initial information and subsequent monitoring to a local certification scheme with relative ease. As we finish writing this paper, one of the regional governments involved in the Interreg projects presented in Section 3 has started an experimental labeling program for dairy and meat products from traditional mountain farms that is largely based on the insights of this research.[8]

The proliferation of eco-labels[9] has been identified as a source of confusion and mistrust among consumers (Brécard, 2014; Moon et al., 2017), which means that the certification system proposed here might have to face the challenges of an overcrowded playing field. The issue will require additional research and cannot be satisfactorily addressed in this paper. However, the effort to bridge any WTP displayed by consumers in an experimental setting and the awareness, motivation, and actual choice of consumers in a real setting is arguably needed in whatever method is chosen to support mountain livestock farms (like in the case of public payments, where one could swap the problem of communicating environmental information to consumers with one of communicating environmental information to voters).

The main limitation of the paper consists of the conventional drawbacks of stated preference methods, which are ultimately based on hypothetical behaviors, although we addressed various potential issues through several robustness checks. As we noted in the introduction, there are no current efforts to explicitly and rigorously market ecosystem services embedded in mountain cheese, so we had no adequate observational alternatives. Future research could address the same research question from a field experiment setting, to combine the advantages of large survey campaigns and observed behaviors in experimental conditions to provide convergent validity to the finding that the value of ecosystem services embedded in mountain cheese supports significantly higher market prices.

CRediT authorship contribution statement

Barbara Cavalletti: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Roles, Writing – original draft, Writing – review & editing. **Matteo Corsi:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Roles, Writing – original draft, Writing – review & editing. **Elena Lagomarsino:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Roles, Writing – original draft, Writing – review & editing.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Acknowledgements

The project was supported by the EU Interreg Program, MARITIME -

[8] Link (in Italian): https://www.lamialiguria.it/it/component/content/article/507-non-categorizzato/ole_2021/12398-ole_2021.html?highlight=WyJldGljaGV0dGEiXQ==&Itemid=437.

[9] See the main database of currently active eco labels at https://www.ecolabelindex.com/.

IT-FR 2014–2020 CAMBIO VIA - CUP G25J19000200007 and PC-IT-FR ALCOTRA 2014–2020 PITEM BIODIVALP PS5- PROBIODIV – CUP B25I19000270007.

The authors are grateful to Dr. Daniela Minetti for the for her long-term support and numerous discussions, to Prof. Ivan Zignego, Prof. Maria Carola Morozzo della Rocca, Prof. Chiara Olivastri, Dr. Giulia Zappia, Dr. Alessia Ronco Milanaccio, and Dr. Xavier Ferrari Tumay for the design of the pictograms, and to the anonymous reviewers for their valuable comments.

Appendix A

The standard theoretical framework to analyze DCE data is the Random Utility Model (McFadden, 1974). A decision-maker n must choose among J alternatives, with each j providing utility $U_{nj} = 1,\ldots,J$. The true value of U_{nj} is known exclusively by n. The researcher observes the choice made and can only assume that n is a utility-maximizing decision-maker that selected the available alternative providing the largest utility. Formally, the utility-maximizing decision-maker chooses j if and only if $U_{nj} > U_{ni} \forall j \neq i$. As utility cannot be directly observed, the observable portion of the decision-making process includes only the attributes x_{nj} of the alternative and, possibly, some characteristics s_n of the decision-maker. Then, the relation between the choice made and the observable portion of the decision process $V_{nj} = V(x_{nj}, s_n)$ has unknown parameters that must be estimated statistically. Reasonably, not every factor adding to the utility of the alternatives is observed, which means $U_{nj} \neq V_{nj}$ and the (unobservable) difference can be represented as $U_{nj} = V_{nj} + \varepsilon_{nj}$ where ε_{nj} is treated as random.

The probability of respondent n choosing alternative i is

$$P_{ni} = Pr\left(U_{ni} > U_{nj} \forall j \neq i\right) = \Pr\left(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj} \forall j \neq i\right) = \Pr\left(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj} \forall j \neq i\right)$$

Different assumptions about the distribution of the random terms representing the unobserved portion of utility lead to various discrete choice models. Under the assumption that ε_{ni} follows an independent and identically distributed Gumbel distribution (McFadden, 1974) what is obtained is the *conditional logit model*, the simplest approach to discrete choice data. The conditional logit model implies preference homogeneity, or, at most, systematic preference variation defined purely in relation to observed variables. Furthermore, conditional logit models imply independence from irrelevant alternatives: the odds of selecting alternative i over alternative j in a choice task equals the odds of a binary choice of i over j. Lastly, conditional logit models cannot account for correlation in unobserved factors over time, which is relevant when more than one choice occasion is observed per decision-maker and data take the panel form.

Mixed logit models provide a more flexible specification that overcomes the limitations of conditional logit models by allowing random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (Train, 2003). The utility that decision-maker n obtains from alternative j at time t can be represented as

$$U_{njt} = \alpha_{(n)j} + \beta_n x_{njt} + \gamma w_{njt} + \delta_j z_{nt} + \varepsilon_{njt} \tag{1a}$$

where $\alpha_{(n)j}$ is a fixed or random alternative-specific constant, the vector of alternative-specific variables x_{njt} has random coefficients β_n varying over decision-makers in the population, the vector of alternative-specific variables w_{njt} has fixed coefficients γ and the vector z_{nt} of case-specific variables (that is, constant over the alternatives faced by the same decision-maker) has fixed alternative-specific coefficients δ_j. The random term ε_{njt} follows a type I extreme value distribution. If β_n varies in the population with density $f(\beta|\theta)$, where θ represents the parameters of the distribution like, for instance, the mean and covariance of the β's, the conditional probability of decision-maker n to select j at time t is

$$P_{njt}(\beta|\theta) = \frac{e^{\alpha_{(n)j} + \beta_n x_{njt} + \gamma w_{njt} + \delta_j z_{nt}}}{\sum_{j=1}^{J} e^{\alpha_{(n)j} + \beta_n x_{njt} + \gamma w_{njt} + \delta_j z_{nt}}}$$

The unconditional choice probability is then the integral

$$P_{njt} = \int \left(\frac{e^{\alpha_{(n)j} + \beta_n x_{njt} + \gamma w_{njt} + \delta_j z_{nt}}}{\sum_{j=1}^{J} e^{\alpha_{(n)j} + \beta_n x_{njt} + \gamma w_{njt} + \delta_j z_{nt}}} \right) f(\beta|\theta) d\beta \tag{2}$$

which must be approximated by simulation. The predicted probabilities for decision-maker n of choosing j at time t are

$$\widehat{P}_{njt} = \frac{1}{M} \sum_{m=1}^{M} P_{njt}(\beta^m)$$

where β^m indicates the random distribution parameters drawn from $f(\beta|\theta)$ and M is the number of draws.

A mixed logit model in willingness-to-pay space assumes ε_{njt} is extreme value-distributed with variance $\mu_n^2(\pi^2/6)$, where μ_n is an individual-specific scale parameter. Under such conditions, equation (1) can be divided by the scale parameter without affecting behaviour, obtaining an error term with the same variance $\pi^2/6$ for all the decision makers. We can therefore rewrite (1) as[10]

$$U_{njt} = \lambda_n Price_{njt} + c_n x_{njt} + \varepsilon_{njt}$$

with $\lambda_n = \beta_{price}/\mu_n$ and $c_n = \beta_n/\mu_n$.

After noting that willingness-to-pay for attributes is defined as $\omega_n = c_n/\lambda_n$ the equation can be further rewritten as

[10] The w_{njt} and z_{nt} terms are omitted to simplify the notation. We also follow the convention adopted in Train and Weeks (2005), Scarpa et al. (2008) and Hole and Kolstad (2012) of foregoing a new notation for U_{njt} and ε_{njt} indicating that the corresponding terms in (1) have now been divided by μ_n. s

$U_{njt} = \lambda_n \left(price_{njt} + \omega_n x_{njt} \right) + \varepsilon_{njt}$

which is the model in willingness-to-pay space properly (Train and Weeks, 2005).

Appendix B

Table B.1
Frequency distribution of social-demographic characteristics of the sample and their answers to supporting questions

Variable	Freq.	%
Sex		
Male	466	49.47
Female	476	50.53
Age		
Up to 30	99	10.51
31 to 40	182	19.32
41 to 50	186	19.75
51 to 60	218	23.14
Older than 60	23	2.44
Education		
None	0	0.00
Elementary school	8	0.85
Middle school	124	13.16
High school	525	55.73
University	233	24.73
Postgraduate	52	5.52
Live with partner		
No	278	29.51
Yes	664	70.49
Live with children		
No	484	51.38
Yes, 1 child	237	25.16
Yes, 2 children	178	18.90
Yes, 3 children	38	4.03
Yes, >3 children	5	0.53
Geographical area		
North-east	184	19.53
North-ovest	238	25.27
Centre	187	19.85
South	230	24.42
Islands	103	10.93
Consumption of cheese		
Frequent	785	83.33
Occasional	157	16.67
How often read labels		
Never	15	1.59
Rarely	52	5.52
Sometimes	233	24.73
Frequently	347	36.84
Always	295	31.32
How often buy organic		
Never	48	5.10
Rarely	175	18.58
Sometimes	387	41.08
Frequently	298	31.63
Always	34	3.61
Buy cheese from producer		
Never	461	48.94
Less than once every 2 months	264	28.03
At least once every 2–3 months	124	13.16
At least once a month	57	6.05
At least once a week	36	3.82
Buy cheese from farmers market		
Never	147	15.61
Less than once every 2 months	292	31.00
At least once every 2–3 months	160	16.99
At least once a month	218	23.14
At least once a week	125	13.27
Buy cheese from local shop		
Never	117	12.42
Less than once every 2 months	225	23.89
At least once every 2–3 months	144	15.29
At least once a month	266	28.24
At least once a week	190	20.17
Buy cheese from supermarket		
Never	10	1.06
Less than once every 2 months	40	4.25

(*continued on next page*)

Table B.1 (*continued*)

Variable	Freq.	%
At least once every 2–3 months	75	7.96
At least once a month	283	30.04
At least once a week	534	56.69
Buy cheese from e-commerce		
Never	752	79.83
Less than once every 2 months	127	13.48
At least once every 2–3 months	51	5.41
At least once a month	12	1.27
At least once a week	0	0.00
How often buy PDO cheese		
Never	19	2.02
Rarely	103	10.93
Sometimes	431	45.75
Frequently	323	34.29
Always	66	7.01
How often driven by ethics		
Never	37	3.93
Rarely	97	10.30
Sometimes	351	37.26
Frequently	381	40.45
Always	76	8.07
If from protected area		
Much less interested	7	0.74
Less interested	10	1.06
Equally interested	153	16.24
More interested	364	38.64
Much more interested	408	43.31

Appendix C

Table C.1
Estimates for choice occasions 1, 2 and choice occasions 7, 8 of respondents

	[5] MXL Gaussian coefficients Choice occasions 1, 2		[6] MXL Gaussian coefficients Choice occasions 7, 8	
Price	−0.396	***	−0.320	***
	(0.04)		(0.03)	
Forage	0.410	***	0.390	***
	(0.07)		(0.06)	
Heritage	0.299	***	0.314	***
	(0.09)		(0.09)	
Ecosystem	0.410	***	0.375	***
	(0.07)		(0.06)	
Ethics	0.075		0.101	*
	(0.06)		(0.05)	
Normal				
sd(Forage)	0.798	***	0.381	***
	(0.12)		(0.12)	
sd(Heritage)	0.738	***	0.807	***
	(0.20)		(0.15)	
sd(Ecosystem)	0.753	***	0.599	***
	(0.12)		(0.10)	
sd(Ethics)	0.465	***	0.331	**
	(0.14)		(0.13)	
ASC				
Either cheese	3.640	***	2.150	***
	(0.45)		(0.34)	
N	942		942	
Ll	−1483.5005		−1568.0453	
Aic	2987.0011		3156.0905	
Bic	3053.3987		3222.4882	

Note: Model 5 corresponds to Model 1without correlated coefficients but is estimated on the subset of observations originating from the first and the second choice task presented to the respondents. Model 6 corresponds to Model 1 without assuming correlation but is estimated on the subset of observations originating from the seventh and the 8 choice tasks presented to the respondents. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors in parentheses.

Appendix D

For small productions employing mostly or exclusively household members, local markets can sometimes be a more realistic outlet than the national market. In that case, the consumer preferences that are relevant for transactions are those of a geographically defined subsample of the population. Table D1 shows WTP estimates from Model 4 but referred to respondents living in each of the NUTS1 territorial units of Italy.

Table D.1
Local variability of WTP estimates across the sample

	WTP estimated from Model] on local subsamples of the population, MXL correlated Gaussian coefficients				
	North-West	North-East	Central	South	Islands
Forage	1.474	1.304	1.533	0.841	1.289
	[1.069 1.878]	[0.748 1.861]	[0.976 2.091]	[0.468 1.214]	[0.789 1.788]
Heritage	0.897	0.471	1.119	0.718	1.019
	[0.358 1.437]	[-0.26 1.200]	[0.462 1.775]	[0.143 1.293]	[0.313 1.726]
Ecosystem	1.406	1.437	1.271	1.086	0.950
	[1.034 1.777]	[0.908 1.966]	[0.756 1.788]	[0.692 1.481]	[0.493 1.407]
Ethics	0.360	0.159	0.421	0.482	0.469
	[0.050 0.671]	[-0.27 0.590]	[0.003 0.838]	[0.147 0.817]	[0.016 0.922]
N	238	184	187	230	103

Note: 95% Confidence intervals in parentheses.

The larger confidence intervals complicate the interpretation of some values, but the overall picture suggests a generalized acknowledgment of the value of the embedded ecosystem services, although some local variability exists. The Central and Island regions assign more value to *Heritage* than the other regions and the South region is also less willing to pay for *Forage*. The confidence intervals for *Ethics* do not include the null value in all regions except the North-East.

Appendix E

Table E.1Coefficients for base labeled models

	8 - MXL Gaussian coef.		9 - MXL Gaussian sel. Two-way		10 - MXL Gaussian sel. Two-way ASC	
Price	−0.326	***	−0.324	***	−0.350	***
	(0.04)		(0.04)		(0.04)	
Forage	0.306	***	0.288	***	0.322	***
	(0.04)		(0.09)		(0.09)	
Heritage	0.082		0.804	***	0.867	***
	(0.12)		(0.30)		(0.31)	
Ecosystem	0.362	***	0.904	***	1.003	***
	(0.09)		(0.23)		(0.24)	
Ethics	0.069		0.074		0.060	
	(0.08)		(0.08)		(0.08)	
Heritage*Ecosystem			−0.371	***	−0.408	***
			(0.14)		(0.14)	
ASC LIGURIA						
Formaggetta (Lig)	2.848	***	1.755	***	0.425	
	(0.40)		(0.56)		(2.34)	
Education					−0.688	**
					(0.34)	
Supermarket					0.517	*
					(0.28)	
PDO					1.044	***
					(0.32)	
Labelinfo					−0.298	
					(0.31)	
Ligurian					−0.035	
					(0.52)	
ASC LOMBARDY						
Formaggella (Lom)	2.955	***	1.868	***	1.140	
	(0.40)		(0.57)		(2.330)	
Education					−0.410	
					(0.346)	
Supermarket					0.610	**
					(0.28)	
PDO					0.959	***
					(0.32)	
Labelinfo					−0.672	**
					(0.31)	
Ligurian					−1.155	**
					(0.52)	
N	138		138		138	

Note: estimates of the standard deviations of the random coefficients omitted for the sake of brevity, are statistically significant with $p < 0.01$. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Standard errors in parentheses.

Table E.2
Estimated WTP for a unit increase in the attributes of regional cheeses

	11 - MXLGaussian coef. in WTP-space		WTP from 9, with MXLGaussian coef.	
			WTP	[95% Confidence intervals]
Forage	1.020 (0.26)	**	0.887	[0.344 1.430]
Heritage	2.073 (0.84)	**	2.475	[0.592 4.357]
Ecosystem	2.493 (0.63)	***	2.784	[1.296 4.272]
Heritage*Ecosystem	−0.927 (0.38)	**	−1.142	[-2.020–0.263]
Ethics	0.018 (0.23)		0.229	[-0.255 0.712]
ASC				
Formaggetta (Lig)	5.456 (1.51)	***	5.402	[2.145 8.660]
Formaggella (Lom)	5.940 (1.53)	***	5.749	
N	138		138	

Note: *p < 0.1; **p < 0.05; ***p < 0.01. Standard errors in parentheses.

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