UNIVERSITY OF WAIKATO

Hamilton
New Zealand

Using flexible taste distributions to value collective reputation for environmentally-friendly production methods

Riccardo Scarpa

Mara Thiene

Francesco Marangon

Department of Economics

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Riccardo Scarpa
Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand

Tel: +64 (0) 7-838-4045
Fax: +64 (0) 7-838-4331

Email: rscarpa@waikato.ac.nz
Web:
http://www.mngt.waikato.ac.nz

Mara Thiene
Department of Land and
Agriculture-Forestry Systems
University of Padua
Legnaro, Padova

Tel: +39049-827-2760
Fax: +39049-827-2703

Email: mara.thiene@unipd.it
Web:
http://www.agraria.unipd.it

Francesco Marangon
Department of Economics
University of Udine
Via Tomadini, 30A
33100 Udine

Tel: +390432-249338
Fax: +390432-249229

Email: marangon@dse.uniud.it
Web:
http://web.uniud.it/dse/

Abstract

In this paper we investigate consumer preferences for various environmentally-friendly production systems for carrots. We use discrete-choice multi-attribute stated-preference data to explore the effect of the collective reputation of growers from an Alpine valley with an established reputation for its environmentally-friendly production: Val di Gresta "the valley of organic orchards". Data analysis of the panel of discrete responses identifies unobserved taste heterogeneity for organic, biodynamic and place of origin along with extra variance associated with experimentally designed alternatives. The assumed parametric taste distributions are each tested using the semi-nonparametric specification proposed by Fosgerau and Bierlaire (2007), while the null of normality cannot be rejected for organic and biodynamic production methods, it is rejected for the place of origin. The latter is found to be bi-modal, with modes at each side of zero. The use of a flexible taste distribution increases the plausibility of this form of heterogeneity and it appears promising for future applied studies.

Keywords

Mixed logit
Flexible taste distributions
Random utility parameters
Collective reputation
Sustainable agriculture
Choice modeling
Environmentally-friendly methods

JEL Classification

C15; C25; Q26

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1 Introduction

Qualitative choice models of food choice have recently attracted much attention and have contributed to casting light on consumer preferences. A review of the international literature shows food related applications investigating a variety of issues. These range from stated choice data analysis of GM food in Europe (Rigby & Burton 2005) to revealed preference data analysis of ethical food marketing systems in Canada (Arnot et al. 2006). Few studies, however, have focussed on the interactions between place of origin, production methods and collective reputation. This is despite evidence that each of these food attributes are of interest to consumers.

Yet, in some disadvantaged regions, the collective reputation of farmers from one location is often built on production methods and is what makes local agriculture economically viable. This is the case in our study area, which is a small valley in the Italian Alps called 'Val di Gresta' (VdG) renown for the organic production of carrots and other vegetables.

Consumers increasingly associate the quality of a given method of production with certification mechanisms (e.g. traceability programmes) based on the product's place of origin (Quagraine et al. 1998, Thomas et al. 2001, Hobbs et al. 2005). Over the last 30 years producers in this valley have invested and gained a solid reputation amongst local consumers for high quality environmentally-friendly products, especially organic. They now enjoy a well-established reputation as organic producers, which is supported by a trademark and trading symbol (a ladybird). However, other environmentally-friendly production methods (EFPMs), such as biodynamic and integrated pest management, could be usefully implemented by these farmers. Our main objective is to explore whether these lesser known EFPMs for vegetables would enjoy the same reputation as the organic method. This requires an understanding of consumer recognition in the market place for new credence attributes. Properly functioning markets have existed for a while for organic products, but this is not so for vegetables produced by integrated pest management (IPM) and biodynamic (BD) (Steiner 1993) methods. These lesser known methods could be viably used to provide vegetables with intermediate degrees of environmental-friendliness, at an intermediate price between food produced with conventional methods and organic food. What is the adequate premium price will depend on the consumer's willingness to pay for them. This is vital information for farmers who intend to diversify their supply on the basis of EFPMs. In addition to this, we explore the link between such methods and the place of origin of the product. In particular, whether consumers are willing to pay for the reputation of the area of production on top of what they are willing to pay for EFPMs.[1]

There is a mounting body of evidence that European consumers have clear preferences over places of origin for foods. Examples can be found in the meat markets which were examined, amongst others, by Roosen et al. (2003), Loureiro & McCluskey (2000). Such preferences are not independent of EFPMs, as shown for oranges, grapes and olive oil by Scarpa, Philippidis &

[1]For studies of IPM on the production and consumption side see Cuyno et al. (2001), Govindasamy & Italia (1998) respectively.

Spalatro (2005), and again for olive oil by Van der Lans et al. (2001) and Scarpa & Del Giudice (2004).[2]

Furthermore, there is theoretical evidence that supports eating quality standards as a means of preventing the dilution of quality amongst groups of farmers enjoying a collective reputation (see the work by Winfree & McCluskey 2005, on Washington apples). In the latter stages of the phase during which collective reputation is being built it is important to identify and measure the magnitude of the premium that consumers are willing to pay for such a reputation. As Winfree & McCluskey (2005) argue, the number of farms sharing such a reputation increases the incentive to depart from the cooperative behavior. In our empirical study in VdG the number of farmers is relatively low so, now that a reputation for quality has been attained, it might be sustained over a long time period.

Because of a lack of existing data from market transactions the data used in our empirical study consist of responses to hypothetical questions about purchasing decisions. The product of reference we chose to study is carrots, which is a common vegetable in the Italian diet, and the place of production is an Alpine valley with the rare characteristic of being totally dedicated to EFPMs: Val di Gresta.[3] All the produce from this valley is strictly produced by means of EFPMs, and certified as such.

Our objective is to try and provide answers to two basic research questions. As described above, the first is whether data from stated choice studies can be used to estimate the 'collective reputation for EFPM' premium. A secondary objective is a methodological one, and it is of potentially wider interest to stated choice practitioners. Since the advent of mixed logit models, food choice analysts have paid increasing attention to the detection, modeling and interpretation of taste variation across people. However, taste variation is often implemented with relatively rigid parametric distributions, typically based on the normal family (normal, log-normal, truncated and SB transformations). So far, computational convenience has been the main reason for such a choice. Yet, it is somewhat worrying that very few studies report sensitivity analyses on the choice of taste distributions. Especially considering that distributional assumptions are known to imply very different population inferences on WTP distributions in discrete choice modeling. In this study we apply a recently proposed semi-parametric approach (Fosgerau & Bierlaire 2007) to the generalization of any parametric base distribution. The proposed generalization gives rise to an easily testable hypothesis within the familiar maximum (simulated) likelihood. It is also conceptually appealing as it allows for multi-modal distributions, which have been found to be behaviorally consistent in other choice contexts (see Scarpa & Thiene 2005, Scarpa, Willis & Acutt 2005, for some examples based on conditional WTP distribu-

[2]We refer the reader to these studies for references about the theoretical basis of production of origin labeling, such as protected designation of origin (PDO), protected geographical indications (PGI), and certificate of specific character (CSC), as defined by EU legislation (EC Regulations 208192 and 208292), which provides protection of food names on a geographical or traditional basis.

[3]The interested reader is referred to www.val-di-gresta.it/ to learn more about this group of producers.

tions). We use the Fosgerau-Bierlaire test to assess the suitability of our assumed parametric distributions in the data.

The remainder of the paper is organized as follows. The following section (2) provides the Italian background to this local applied study, while the local issues are presented in section 3 along with a description of the EFPMs, the survey design and the data. Section 4 describes the methods of data analysis and the hypotheses tested in model estimation. Estimation and results are illustrated in section 5, while section 6 concludes.

2 Low environmental impact agriculture in Italy

In the past ten years environmentally-friendly production methods have experienced rapid development in the EU. Politicians who are engaged in designing policies to jointly deliver farm income security and enhanced environmental standards are interested in the potential for double-dividends, i.e. the scope to jointly improve environmental conditions and produce foods that can command a premium in the market place, so as to make the production of such products self-sustaining.

Amongst EFPMs organic farming is the method that has been most successful in Italy, while BD and IPM are still quite uncommon. The recent growth in organic farming in Italy is due to several factors. From the supply side the dominant one is widely agreed to be the substantial flow of subsidies used to create incentives for organic food production. From the domestic demand side there is increasing consumer recognition and *WTP* for organic products, in the aftermath of various food scares which have afflicted Europe (Santucci & Pignataro 2002).

In 2001, Italian organic agriculture covered 1,240,000 hectares and more than 60,000 farms were involved making it the third country in the world and the first in Europe in terms of value of organic produce. More recently the growth trend seems to be reversed, as in 2002 both number of farms and area cultivated decreased by 7.6% and 5.6%, respectively. This reversal is partly due to loss of subsidies and other incentives brought about by the new agri-environmental measures of the EU Common Agricultural Policy.

Most of the Italian land used for organic production is used for permanent pastures or fodder crops (54%) and is concentrated in a few districts (regions), located in the major islands (Sardinia and Sicily) and the South of Italy, which account for almost 58% of the total organic agricultural area and host the majority of organic farms (61%). Since 2002 these regions have witnessed the strongest decrease. In the Center-North, instead, land use for organic production has increased, but only slightly. Perhaps this is due to the higher value-added of organic products since, especially in the North, many organic farms show a sophisticated degree of vertical integration (i.e. many transform and market their produce collectively and/or directly). Also, produce from farms in the North travels a shorter distance to market since most of the demand for organic is also located in this area of the country (Marino 2004). Now that the concept of ‘food miles’ has been embraced by many environmentally inclined consumers, as an indicator of the carbon cost of food, more people favor local produce.

2.1 Consumer perception of quality and purchase behavior

It is estimated that only 5% of Italian consumers regularly purchase organic food, but at least one consumer out of three does so occasionally (Torjusen et al. 2004). In 2003 the expenditure for organic food in Italy was estimated to be 1.3 billion $US, or about 1.5% of household expenditure on food (ISMEA 2004).

But what is the perception of quality in organic food in Italy? In the last decade organic products have received greater attention from Italian consumers. There is a growing demand for food produced with environmentally-friendly techniques, which can be linked to a number of factors:

- an increased consumer awareness about human health and environmental issues,
- the development of rural communities as a consequence of a return to the countryside by a section of previously urban population (especially retired people)
- and the concern for food safety.

Added to these, an increasing concern for the greater mileage associated with food imports, especially for out-of-season fruit, and its repercussions on green-house emissions, drives a preference for locally grown food.

Since the end of the ’90s, several studies have investigated household preferences for environmentally friendly production, focusing on those qualitative and quantitative attributes driving organic products sales in Italy (Canavari et al. 2002). Despite much empirical work, the structure of household preferences is still poorly understood. In the beginning Italian consumers of organic products were mostly motivated by ecological awareness. They were simply looking for food derived from lower-impact agriculture. More recently, in addition to these environmental concerns, consumers also focus on food safety and security. According to a nation-wide survey (ISMEA 2002), the main reason for purchase seems to be linked to the absence of chemicals harmful to health; secondly organic products are perceived to be better monitored by regulating authorities; thirdly there is the ‘in-any-case-they-won’t-do-any-harm’ attitude. Environment-related motivations were quoted only fourth, this ranking being shared with other European consumers (Zanoli et al. 2001). At present it would appear that health motivations are the leading ones for both regular and occasional organic consumers. The latter seem more concerned with personal satisfaction derived from organic food consumption, while regular consumers seem to show more altruistic values, associated to children’s welfare and the rural environment (Zanoli & Naspetti 2002).

Official statistics on consumer expenditure on environmentally-friendly products show that this is distributed over almost all categories of products. Amongst them, dairy products account for 25%, fruits and vegetables and bread and biscuits both 14%, beverages 10% and eggs 6%. Not surprisingly, organic meat is still almost absent, because this sub-sector still needs to be properly organized. Although all sectors showed very strong growth in past years (+80% in 2001-2000), 2002 signalled a trend reversal, as mentioned above, with a substantial standstill (ISMEA 2004).

According to a recent study (ISMEA 2002), organic consumers in Italy can be divided into five groups. For identification purposes these have been labeled as: 'historical', 'supermarket', 'occasional', 'taster' and 'I wish, but I can't' consumers. The first group accounts for 30% of Italian organic consumers, but generates 60% of total expenditure. The 'supermarket' consumers are as numerous as the previous group but account for a lower share of expenditures (30%) and mostly live in Northern Italy. They represent a very interesting segment in terms of marketing strategy since their supermarket purchases are usually impulse-driven. 'I wish I could' is an emerging segment, with a limited economic weight (6%) but much promise. They are mostly young people living in the Center and South of Italy. Finally, the 'taster' segment is a very small one (1%) with medium-high income, very low information about organic, who buy organic food only very occasionally.

On the demand side price remains a crucial factor as the retail price difference between conventional and organic is still quite high (Zanoli & Naspetti 2002). Heterogenous reliability of supply is still an obstacle to consumption growth through the large distribution channels. Finally, according to Zanoli & Marino (2002) satisfying the need for ancillary information—about place of origin, methods of production and modes of monitoring—are other important issues for developing demand.

3 Collective reputation of Val di Gresta's growers

It is with this backdrop that we engaged in the study of VdG produce. This valley is located in the mountains of the Trentino region, in the North East of Italy. It is located between 400 to 1,300 meters above sea level. The hill slopes are terraced and tend to have a South-Westerly aspect, thereby receiving a long daily exposure to solar radiation. Because of this and its proximity to Garda Lake—Italy's largest lake—the valley enjoys a warm micro-climate, particularly suitable for growing vegetables that can be placed in the market early on in the season, thereby capturing a premium over the produce marketed in full season.

Vegetables—mainly cabbages and potatoes—have been grown in the valley since the beginning of the last century. Cultivation of carrots was introduced during the '40s, while at the beginning of the '70s several other kinds of vegetables were introduced. More than 20 types of vegetable are currently grown in the valley. The particular vocation of the area to vegetable cultivation is due to the good differentiation of soils along the valley. Agricultural products from VdG have a reputation that goes beyond the local markets in the Trentino Region, as 80% of the products are marketed outside of this Region. The area of the valley destined to vegetables exceeds 100 hectares, which is quite surprising when considering that it is organized in terraced plots with each terrace occupying 1,000 square meters, or less.

The VdG Fruit and Vegetable Producers' Association is a farmers' cooperative founded in 1969, on the basis of an pre-existent association founded in the '40s. This farmers' cooperative is the largest in the area and it supplies an average of 2-2.2 thousand metric tons of fruits and vegetables per year.Other produce includes cucumbers, onions, beans, salads, apples, and kiwis. Produce grown using organic methods accounts for 70% of all environmentally-friendly produce, the remaining fraction being grown using IPM and BD methods.

Carrots represent one of the most important products of the VdG and are mostly produced by organic farming, and in a much smaller quantity by IPM. This vegetable is available from July till March and production in 2003 was 25 metric tons for organic carrots, and 5.5 for IPM. With such small scale production it is difficult to measure consumer recognition of the collective reputation for the VdG origin starting from market transactions. Furthermore, although the BD methods are just as applicable to farming carrots as to other produce in the valley, they are not used for this crop.

3.1 Description of production methods

Apart from the main question of how consumers reward producers for their collective reputation, our objective is to explore whether less common forms of environmentally-friendly production methods (BD and IPM methods) are distinctly recognized by consumers and may hence command a price differential. Because they are both lesser known environmentally friendly methods we relate them both to organic production. It is reasonable to expect that the reputation currently enjoyed by farmers in organic production amongst consumers may extend to the two lesser known environmentally friendly methods in the case they were adopted as subsidiary methods.

3.1.1 Biodynamic production

Biodynamics (BD) was defined in 1924 by Dr. Rudolf Steiner a Yugoslavian brought up in the Austro-Hungarian empire who pioneered a philosophical approach to science called anthroposophy. According to the Biodynamic Farming and Gardening Association:

> 'Biodynamics is a science of life-forces, a recognition of the basic principles at work in nature, and an approach to agriculture which takes these principles into account to bring about balance and healing,..., an on-going path of knowledge rather than an assemblage of methods and techniques'.

Dr. Steiner emphasized the importance of the many forces within living nature, identifying many of the factors and describing specific practices and preparations that enable the farmer or gardener to work in concert with these forces. Central to the biodynamic method are certain herbal preparations that guide the decomposition processes in manures and compost.[4]

3.1.2 Integrated pest management production

The Council Directive 91/414/EEC of 15 July 1991 (and following amendments) concerning the placing of plant protection products on the market (article 2), defines 'integrated control' (IPM) as:

> 'the rational application of a combination of biological, biotechnological, chemical, cultural or plant-breeding measures whereby the use of plant protection products is limited to the strict minimum necessary to maintain the pest population at levels below those causing economically unacceptable damage or loss'.

IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. It focuses on a careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep plant protection products and other interventions to levels that are economically justified in order to reduce or minimize risks to human health and the environment.

The three EFPMs can be placed in a gradient of 'environmental-friendliness' which goes from organic, as the most friendly, to BD, which is the least well known, to IPM, the least friendly. This gradient might be expected to be reflected in the mean *WTP* for each method, so that conditional on consumer knowledge of the production method, mean *WTP* for organic is expected to be higher than that for BD, and this in turn is expected to be higher than IPM.

Because environmentally-friendly carrots are also produced outside VdG, to identify the specific combined effect of being from Val Di Gresta and produced with each of these methods we used interaction effects between each EFPM *and* VdG origin. Such effects, if present, will constitute our measure of the acquired reputation for these methods by the farmers of the valley. In particular, while there is a well established certification process for organic and IPM produce for VdG products, the certification process for BD produce is only very recent (2003) and does not have a clearly established reputation. The short history for this attribute makes it difficult to use revealed preference data to determine such an effect, hence our reliance on data from a stated preference survey.

[4]More information can be obtained at: Biodynamic Farming and Gardening Association (www.biodynamics.com); and Biodynamic Agriculture/Biodynamic Farming, Sustainable Agriculture: Definitions and Terms, USDA (http://www.nal.usda.gov/afsic/AFSIC_pubs/srb9902.htm)

3.2 Survey and data

The survey instrument was calibrated via focus groups and a pilot study in early summer 2004, while the final survey data were collected through face-to-face interviews during summer and autumn 2004. Respondents were randomly selected from buyers of carrots at supermarkets and grocery shops in the region of Trentino Alto Adige (North-East of Italy). Eventually a total of 240 completed surveys were collected.

In the creation of the choice-tasks used in the survey attributes and attribute levels were arranged according to an experimental design that guaranteed the identification of the effects of interest in an efficient way. The complete experimental design was a fractional factorial that identified main effects and 2-way interactions. It was derived using the D-optimality criterion using Design Expert v. 6. It consisted of 41 choice tasks. Each choice task comprised the no-buy option and two experimentally designed alternatives. Choice tasks were divided in five separate blocks with D-optimal properties.[5] Respondents performed either 8 (blocks 1-4) or 9 (block 5) choice tasks. There were five product attributes including certification of production method (conventional, BD, IPM and organic), certification of origin (VdG, elsewhere), skin imperfections (absent, 'some' e.g. less than 10% of the skin, ' a lot' e.g. more than 10% of the skin), packaging (pre-packaged or loose) and finally, retail price per kg (€1.3, €1.5 and €2.2). An example of choice task is reported in table 1. The experimental design included carrot profiles in which each production method was not associated with VdG, so as to isolate the effect of place of origin. This included conventionally produced carrots from VdG as this is a realistic option since farmers are voluntarily adhering to the cooperative of producers, but might choose to switch to conventional production if they so wished. Information on the definition of the various EFPMs was not provided to respondents, the observed choices were therefore contingent on previous knowledge.

In the second section of the questionnaire, we collected socio-economic data and asked some information about the respondent's attitude towards organic product consumption. Looking at the sample characteristics, the average age of the respondents is 50 years old. 66% of those interviewed are women and 34% are man. 19.5% of the sample has a university degree, which is definitely a large fraction for Italian standards. The average family size is 2.8 members and 40% of the respondents have children aged under 12. 88% of respondents were usually in charge of grocery shopping.

[5] Interactions between attribute levels can be identified with adequate designs and allow the estimation of utility functions with 2-way interactions—i.e. those between each pair of attributes. D-optimality refers to the maximization of the information content as measured by the information matrix.

4 Method

4.1 The basic RUM model with random taste and error components

Consider the utility definition for a typical choice-task amongst three alternatives, one of which is the no purchase alternative:

$$U(int) = \begin{cases} V(x_{int}, \tilde{\beta}_n, \beta, \varepsilon_n) + \epsilon_{int}, & \text{if } i = 1; \\ V(x_{int}, \tilde{\beta}_n, \beta, \varepsilon_n) + \epsilon_{int}, & \text{if } i = 2; \\ V(ASC) + \epsilon_{int}, & \text{if } i = \text{no-buy}; \end{cases} \tag{1}$$

where n denotes the individual, i the alternative and t the choice-occasion. V_{int} is indirect utility, which is a function of a vector of variables explaining choice x_{jnt}, and suitably chosen vectors of individual-specific $\tilde{\beta}_n$ and fixed β parameter to estimate, while ε_n is an error component (Brownstone & Train 1999, Train 2003) associated with each of the experimentally designed alternatives involving purchase in each choice set (i.e. $\varepsilon_n = 0$ for the no-purchase option). This is an additional error component to the conventional Gumbel-distributed error ϵ_{nit} of the multinomial logit model. The additional flexibility that error-components can induce in the covariance structure of choice models is illustrated in detail by Herriges & Phaneuf (2002). In this case it is meant to capture additional variance associated with the cognitive effort of evaluating a hypothetical purchase as suggested in Scarpa, Ferrini & Willis (2005) and Ferrini & Scarpa (2007).

The basic specification for the choice probability is conditional logit. That is, conditional on the individual-specific random tastes $\tilde{\beta}_n$ and error-components ε_n, the probability of selection by respondent n of a specific alternative i in choice t of the sequence $\langle t = 1, \ldots, T\rangle$ from the choice-set containing the generic alternative j is logit:

$$\Pr(int|\tilde{\beta}_n, \beta, \varepsilon_n) = \frac{e^{V(x_{int}, \tilde{\beta}_n, \beta) + \varepsilon_n}}{\sum_{j=1}^{j=3} e^{V(x_{jnt}, \tilde{\beta}_n, \beta) + \varepsilon_n}}. \tag{2}$$

Assuming independence across the T choices by the same individual n, the joint probability of a sequence of choices $\langle i_{t=1}, i_{t=2}, \ldots, i_{t=T(n)}\rangle$ by one individual is:

$$\Pr(\langle i_{t=1}, i_{t=2}, \ldots, i_{t=T}\rangle_n|\tilde{\beta}_n, \beta, \varepsilon_n) = \Pr(n|\tilde{\beta}_n, \beta, \varepsilon_n) = \prod_{t=1}^{t=T(n)} \frac{e^{V(x_{int}, \tilde{\beta}_n, \beta) + \varepsilon_n}}{\sum_{j=1}^{j=3} e^{V(x_{jnt}, \tilde{\beta}_n, \beta) + \varepsilon_n}}. \tag{3}$$

Notice that although independent the choice-probabilities all share the same draw for the random taste parameter $\tilde{\beta}_n$ or/and error component ε_n, thereby accounting for stability of preferences across a sequence of choices by the same individual n, and inducing correlation amongst probabilities of choice by the same individual. The sample likelihood will simply be the product of each respondents' choice probabilities:

$$\mathcal{L} = \prod_{n=1}^{N} \Pr(n|\tilde{\beta}_n, \beta, \varepsilon_n). \tag{4}$$

Randomness of taste-intensities is represented by the choice of one appropriate distribution $g^k(\cdot)$ for each element k of $\tilde{\beta}_n$ whose dimension is K. Each $g^k(\cdot)$ is completely defined by the combination of location (μ^k) and scale (σ^k) parameters.[6] The additional alternative-specific error-component ε_n is assumed to be (normally distributed) white noise and therefore is centered on zero, but with a variance σ^2. So, one can write $\varepsilon_n \sim \mathcal{N}(0, \sigma^2)$ or just $\varepsilon_n \sim \phi(\sigma^2)$.

The probability of choice unconditional on the error-component is obtained by integrating equation 6 over the error-component space:

$$\Pr(n, \varepsilon_n|\tilde{\beta}_n) = \int_{-\infty}^{\infty} \Pr(n|\varepsilon_n, \tilde{\beta}_n)\phi(\sigma^2)d\varepsilon_n, \tag{5}$$

while, the marginal probability of choice is derived by further integrating expression 2 over the appropriate distribution functions for the K random parameters:

$$\Pr(n, \tilde{\beta}_n, \varepsilon_n) = \int_{-\infty_{k=1}}^{\infty} \dots \int_{-\infty_{k=K}}^{\infty} \Pr(n, \varepsilon_n|\tilde{\beta}_n) g^1(\tilde{\theta}^1|\cdot) \dots g^K(\tilde{\theta}^K|\cdot) d\tilde{\theta}^1 \dots d\tilde{\theta}^K, \tag{6}$$

where we ignore β as this is fixed and need not integration over any density. Finally, the sample log-likelihood $\ln \mathcal{L}$ is given by the sum across respondents of the log of the probability of sequences:

$$\ln \mathcal{L} = \sum_{n=1}^{N} \ln \Pr(n) = \sum_{n=1}^{N} \ln \Big[\Pr(n, \tilde{\beta}_n, \varepsilon_n)\Big]. \tag{7}$$

Because equations 6 and 5 have no closed-form in estimation they are simulated (Train 2003) by averaging the probabilities computed at a sufficiently high number of draws with good equidispersion properties, so as to practically reduce estimation time, without compromising accuracy.[7]

[6] We intentionally borrow the notation of the normal distribution, although $g^k(\cdot)$ need not be normal.

[7] (Hess et al. 2006) reports that Latin Hypercube sampling has more desirable properties than Halton draws, and we employed 350 Latin Hypercube draws in our estimation.

4.2 Testing the suitability of the assumed distribution of tastes

The decision of what product attributes to associate with random coefficients and hence giving rise to a random *WTP* is based on the model performance on the available data. We tested a series of models allowing each taste parameter to be variable according to a chosen distribution. For practicality we kept the marginal utility of income non-random. This is commonly assumed in the literature.

A potentially crucial assumptions is that of the choice of mixing distribution for taste across respondents. Yet, testing this assumption has been seen as so problematic that most papers that have dealt with distribution choices have focussed on developing expedients to obtain behaviorally more plausible results than with the fitting of more flexible, and hence better fitting distributions.[8] In this paper we adopt a recently introduced method by Fosgerau & Bierlaire (2007). The test is based on a mixing (cumulative) distribution $G(\tilde{\beta}_n)$, which represents a semi-parametric generalization of the base parametric distribution $F(\tilde{\beta}_n)$ obtained by means of a monotone function mapping from [0,1] into [0,1] and based on orthogonal Legendre polynomials. Using this approach the generalized density can be written as:

$$g(\tilde{\beta}_n) = q(F(\tilde{\beta}_n))f(\tilde{\beta}_n), \tag{8}$$

where $q(x) \approx K^{-1}q_N^2(x)$, $q_N = 1 + \sum_{k=1}^{N} \delta_k L_k(x)$, and $K = \sum_{k=1}^{N} \delta_k^2$, so as to allow the cdf integral to equal 1. Fosgerau & Bierlaire (2007) show that even with few (i.e. 2-3) polynomial terms this specification allows for great flexibility and because $G(\tilde{\beta}_n)$ equals $F(\tilde{\beta}_n)$ when all $\delta_k = 0 \forall k$, the testing of the null is simple in the context of (simulated) maximum likelihood estimation as it only requires a likelihood ratio test. Furthermore, the polynomials have a recursive formula that facilitates their implementation:

$$L_n(x) = \frac{\sqrt{4n^2-1}}{n}(2x-1)L_{n-1}(x) - \frac{(n-1)\sqrt{2n+1}}{n\sqrt{2n-3}}L_{n-2}(x), \tag{9}$$

where n denotes the order of the polynomial. In our case we assume the base distribution to be normal, so that we can write it as $F(\tilde{\beta}_n|\mu, \sigma)$, and hence the generalised one is denoted by $G(\tilde{\beta}_n|\mu, \sigma, \delta_k)$.

4.3 Error component for the purchase alternatives

The presence of a no-buy option is known to modify the substitution patterns within the alternatives of even relatively simple choice situations, thereby undermining the logit assumption of

[8] Amongst the various alternative approaches put forward to mitigate such negative effects we mention the work by Train & Sonnier (2005) based on bounded transformations of normal variates, already employed in food choice study by Rigby & Burton (2006), and the work by Hensher & Greene (2003) on bounded triangular distributions.

independence of irrelevant alternatives. The simple inclusion of an alternative-specific constant (ASC) for the no-price option cannot account for such a violation. Previous attempts to address this issue used the nested logit model (Haaijer et al. 2001), which is not a panel estimator. Some more recent Monte Carlo results (Scarpa, Ferrini & Willis 2005) suggest that error-component models show robustness to mis-specification. An additional advantage of these is that they also account for the panel nature of the choice experiment data. This latter feature makes them preferable to the widely used nested logit models, which also share the advantage of accounting for a different covariance structure across utilities of experimentally designed alternatives and those of the no-buy option. We build on this result and note that results on our data cannot refute the presence of extra variance from a zero-mean normal error component associated with the two alternatives involving purchase in each choice-set. This is the case for both the preference-space and *WTP*-space specifications.

4.4 *WTP* estimation

We focus on marginal *WTP* for attributes. With the conventional approach of linear-in-the-parameter indirect utility in the preference space we have:

$$V(x_{jnt}, \tilde{\beta}_n, \beta, \varepsilon_n) = \sum_{k=1}^{K} \tilde{\beta}_n^k x_{jnt}^k + \sum_{m=1}^{M} \beta^m x_{jt}^m + \alpha cost + \varepsilon_n, \tag{10}$$

where k denotes random taste intensities and m denotes fixed ones. With a fixed cost coefficient α conditional on the individual-specific random parameters β_n, the marginal *WTP* for a choice attribute x^k can be shown to be equal to $\widehat{E}[WTP|\beta_n] = -\hat{\beta}_n/\hat{\alpha}$, where $\hat{\beta}$ indicates the generic taste-intensity parameter and $\hat{\alpha}$ the non-random cost-coefficient.[9] When $\hat{\beta}$ is assumed to be random ($\beta \in \tilde{\beta}_n$) according to the semi-parametric mixing distribution $g(\tilde{\beta}_n|\mu, \sigma, \delta_k)$ the estimator must be changed accordingly:

$$\widehat{E}[WTP] = \int_{+\infty}^{-\infty} \frac{-\tilde{\beta}_n}{\hat{\alpha}} d\tilde{\beta}_n g(\tilde{\beta}_n|\mu, \sigma, \delta_k) = \alpha^{-1} \int_{+\infty}^{-\infty} -\tilde{\beta}_n d\tilde{\beta}_n g(\tilde{\beta}_n|\mu, \sigma, \delta_k). \tag{11}$$

Similarly, one can derive by numerical approximation the integral for the variance and the inverse cumulative distribution function for the quantiles.

In the remainder of this section we explain how we tackle each of the important modelling decisions involved in the specification testing of complex mixed logit models with continuous mixtures. The decisions we focus on are the selection of variables with heterogeneity, the choice of mixing distributions, and the error component variables.

[9] We note that with interaction terms the numerator will include more than one term.

4.5 Hypotheses

The hypotheses to be tested concern the following:

1. relevance of environmentally-friendly production methods (EFPMs) in consumer choice, and—importantly for our measure of collective reputation—their interactions with place of origin (VdG);

2. the presence of unobserved heterogeneity or randomness in parameters of taste intensity, which can be identified by a significant dispersion parameter estimate $\hat{\sigma}_\beta$;

3. the presence of extra variance in experimentally designed alternatives involving purchase, which can be identified by a significant dispersion parameter estimate for the error component $\hat{\sigma}_\varepsilon$. This makes the variance of utilities associated with purchase substantially higher than the variance of no-purchase utility. For example, with normally distributed tastes and error components we have:

$$Var\left[U_{int}\right] = \sum_k Var(\tilde{\beta}_n) + Var(\varepsilon_n) + Var(\epsilon_{it}) = \sum_k (\sigma^k)^2 + \sigma_\varepsilon^2 + \pi^2/6; \quad (12)$$

4. the improvement of the generalized mixing distribution over the hypothesized normal for taste intensities, which can be identified by the significance of the inclusion of first, second an third order Legendre polynomials.[10]

Throughout we use the maximum simulated likelihood estimator as implemented in BIOGEME v1.5 (Bierlaire 2003) using the CFSQP algorithm for non-linear models developed by Lawrence et al. (1997).

5 Model evaluation and testing of hypotheses

5.1 Deriving a base model specification

The method of investigation follows the typical steps of a modern qualitative choice analysis of preferred choices amongst systematically varied alternatives. We start with a basic multinomial logit model specified on the main attributes (Model 1 in Table 2) which does not account for correlation across choices by the same respondent, nor does it include interaction effects between EFPMs and place of origin while it does impose the restrictive I.I.A. assumption. This model is reported as a benchmark that incorporates restrictions on all other models. We note,

[10] Because of the Monte Carlo results reported in Fosgerau & Bierlaire (2007), we hold 0.01 as a significance level.

however, that in this model the estimate of taste intensity of the ‘VdG’ variable is positive and more significant even than cost. This is consistent with evidence in favor of a consumer’s reputation of carrots with this origin. Taste intensity for ‘Organic’ is also strongly significant and positive, and so are the coefficients for skin imperfections, which are visual indications of true EFPMs production methods, as consumers know that absence of skin imperfection in carrots can only be uniformly achieved via conventional practices based on pesticide use. Neither IPM nor biodynamic production show significance in this model.

We then proceed, using a bottom-up approach, by gradually testing the introduction of a category of parameters associated with the various hypotheses surrounding two separate issues: (*a*) taste heterogeneity and (*b*) the correlation of utilities via the presence of an additional error component for the ‘buy’ alternatives.

The specification search for the first issue identified Model 2 as the best fitting specification, which identifies as significant the taste heterogeneity for BD, organic and VdG origin, but not for IPM. The second issue was addressed simultaneously with the significance of interaction variables between EFPMs and place of origin. This last issue constitutes a core hypothesis in support of the collective reputation of the VdG producers. The specification search led to a series of models from which we chose to present Model 3, the best fitting one. We note that addressing these two issues separately produces an increase in the pseudo-R^2 from 0.21 in Model 1 to 0.27 in Model 2 and 0.28 in Model 3. We interpret this as strong evidence in favor of both issues. The results so far show that we cannot rejects hypotheses 1-3 as stated in section 4.5.

Model 4 simply addresses issues (*a*) and (*b*) jointly, and produces a further increase in pseudo-R^2 to 0.31. With these results we can conclude that the data support the presence (1) of a positive ‘reputation effect’ of EFPM products from VdG; (2) a covariance between utilities related to purchasing options, and (3) the presence of substantial taste heterogeneity for organic, biodynamic and place of production.

5.2 Testing the appropriateness of taste distributions

Model 4 represents the final model in a conventional search, but this model is reliant on the adequateness of the normal distributions to describe the randomness of taste for biodynamic, organic and the VdG attributes.

To test our fourth hypothesis, i.e. whether our data is consistent with null of the distributions of taste intensities being normal, we use the test described in section 4.3. We test the null that a flexible (or ‘generalized’) taste distribution $G(\beta_n|.)$ produces a significant improvement in the model fit. That is, we introduce first, second and third order polynomial effects in turn. Then 2 at a time, and finally all 3 for each attribute. These should capture most of the functional flexibility afforded by such a generalization. If an addition proves to be significant in terms of an increased fit as measured by a formal likelihood ratio test at 0.01 significance, then the random taste is deemed to be distributed $g(\beta_n|\hat{\mu}, \hat{\sigma}, \hat{\delta}_1, \hat{\delta}_2, \hat{\delta}_3)$ instead of $\phi(\beta_n|\hat{\mu}, \hat{\sigma})$ for the *WTP* estimation.

The test statistics and relative p-values for this search are reported in Table 3. As can be seen only for the VdG attribute do we find significance of the generalized flexible distribution since the fitting of the 3 polynomials of the series results in a p-value of less than 0.001. Model 5 in Table 2 reports the estimates of such generalization. We note how the pseudo-R^2 is highest for this model, with a value of 0.33.

In Figure 1 we plot the estimated densities for VdG from Model 4 and Model 5 as a comparison. The polynomial generalized distribution implies a bi-modality which is behaviorally quite plausible, but fails to be captured by the normal. Allowing for extra flexibility than the one naturally accommodated by the normal reveals there is a bi-polar structure in the taste distribution for VdG origin, most people like it, but a minority dislikes it. Such a preference structure has repercussion in the distribution of *WTP* via the interaction terms with VdG, as is exemplified by the comparison of the statistics for the *WTP* distributions (quantiles and mean *WTP*) in Table 4. Focussing only on the mean, it is evident that Model 5 implies a value of €0.44 more for organic carrots from VdG than Model 4, biodynamic from the valley is valued €0.39 more, while there is little difference in IPM.

6 Conclusions

We developed a choice-experiment to investigate consumer preferences over environmentally-friendly production methods (EFPMs) in carrots produced in a distinctive Alpine valley (VdG) where producers have been investing in building a collective reputation for the last three decades. To address unobserved taste heterogeneity we investigate the consequences of different specifications of mixed logit models. The results show significant interaction effects between place of origin and EFPMs thus providing evidence in favor of collective reputation and substantial taste heterogeneity for EFPMs and place of origin.

Further investigation of the nature of taste distribution by means of the test proposed by Fosgerau & Bierlaire (2007) results in rejection of normality for the attribute VdG origin in favor of a generalized semi-parametric distribution which implies bi-modality of taste intensities. The results from the best fitting model imply that VdG carrots produced using integrated pest management practices can fetch a mean *WTP* of €0.82/kg (median €0.36/kg). Biodynamic carrots from VdG—instead—command a mean *WTP* of only €0.58/kg (median €0.12/kg). In terms of policy direction it is clear that the indication from this study is toward favoring IPM production rather than biodynamic. The best EFPM is confirmed to be the organic with a mean *WTP* premium of €1.92/kg (median €1.46/kg).

The use of a more flexible distribution than the normal to describe taste heterogeneity proved to be valuable. It improved model fit and captured significant differences in the key attribute of place of origin. This enters, via interaction terms, the structure of indirect utility used in this study to describe the premium for collective reputation in EFPMs. So, features of its distributions are reflected in distributions of *WTP* derived from its interactions with other attributes. For example, all *WTP* distributions derived from the model with the generalized distribution of taste for VdG origin are skewed with a median much smaller than the mean. More attention should be directed towards the effects of distributional assumptions and their substantive consequences in choice modeling studies. For example, in this study the difference in estimated median *WTP* for IPM from VdG obtained by incorrectly imposing normality is more than twice that obtained by allowing for a more flexible distributional assumption.

Investment on collective reputation is an avenue through which producers located in marginal areas can secure customer loyalty and increase their revenues, thereby decreasing reliance on external subsidies. Stated choice methods once again seem to produce valid and reliable estimates that can be used to direct policy.

7 Tables

Attribute	*Alternative* A	*Alternative* B	*Buy neither*
Production method	Organic	Conventional	
Origin VdG	Yes	No	
Skin imperfection	more than 10% of the skin	absent	
Packaged	Yes	loose product	
Price in Euro	1.30	2.22	

Table 1: Example of choice task in choice experiment.

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	Model 1	*Model* 2	*Model* 3	*Model* 4	*Model* 5
Fixed parameters					
Cost	–0.79 (10.6)	–1.14 (8.5)	–0.80 (8.9)	–1.08 (8.5)	–1.10 (8.5)
ASC no-buy	–1.70 (9.6)	–2.29 (7.2)	–3.80 (9.7)	–3.96 (9.4)	–3.92 (9.0)
Bio-dynamic	–0.02 (0.1)		–0.44 (1.3)		
Organic	0.70 (9.3)		0.15 (0.5)		
Val Gresta	0.71 (12.6)		0.14 (0.5)		
Integr. pest mgmt.	0.02 (0.1)	–0.33 (1.2)	–0.70 (2.1)	–0.78 (2.1)	–0.72 (2.0)
Packaged	–0.06 (1.0)	–0.11 (1.2)	–0.06 (0.9)	–0.09 (1.1)	–0.09 (1.0)
Some skin imperf.	0.52 (3.3)	0.69 (3.8)	0.63 (2.9)	0.78 (3.4)	0.83 (3.7)
No skin imperf.	0.48 (6.6)	0.76 (7.2)	0.48 (6.3)	0.71 (7.0)	0.73 (7.2)
Org. $\times$ Val Gresta			0.82 (2.2)	1.13 (2.5)	1.33 (2.4)
Biod. $\times$ Val Gresta			0.51 (1.3)	0.67 (1.4)	0.75 (1.6)
IPM $\times$ Val Gresta			0.98 (2.2)	1.35 (2.4)	1.10 (2.5)
Random parameters					
Biodynamic $\hat{\bar{\beta}}$		–0.36 (1.3)		–0.69 (1.9)	–0.63 (1.7)
Biodynamic $\hat{\sigma}$		1.62 (6.9)		1.47 (6.5)	1.54 (6.2)
Organic $\hat{\bar{\beta}}$		0.47 (1.8)		0.24 (0.8)	0.28 (0.9)
Organic $\hat{\sigma}$		1.20 (7.0)		1.00 (6.4)	0.94 (5.1)
Val Gresta $\hat{\bar{\beta}}$		0.42 (1.7)		0.23 (0.8)	0.61 (1.9)
Val Gresta $\hat{\sigma}$		1.43 (9.3)		1.13 (7.6)	1.59 (7.2)
Error components					
ASC buy $\hat{\sigma}_\varepsilon$			2.61 (9.0)	2.68 (8.9)	2.69 (8.1)
Coefficients of polynomials					
Polynomial 1 $\hat{\delta}_1$					–0.18 (1.6)
Polynomial 2 $\hat{\delta}_2$					–0.17 (1.7)
Polynomial 3 $\hat{\delta}_3$					0.74 (5.2)
Pseudo-R^2	0.21	0.27	0.28	0.31	0.33
$\ln \mathcal{L}^*$	–1,683	–1,552	–1,528	–1,458	–1,441
Bayes IC	3,415	3,170	3,128	3,005	2,987
Akaike IC	3,384	3,129	3,083	2,950	2,921
Observed choices = 1,949, Respondents = 240					

Table 2: MSL estimates for the preference-space models. In round parenthesis absolute values of z-statistics, obtained with 350 Latin hypercube draws.

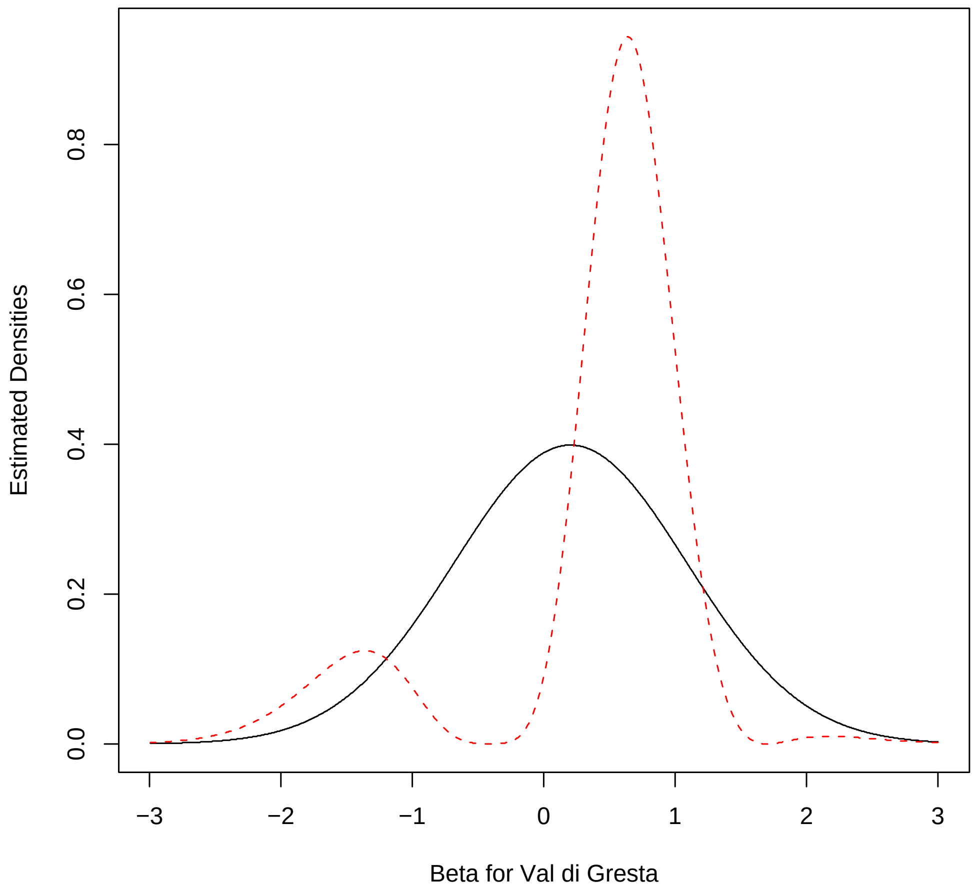
	Biodynamic			Organic			VdG		
Coeff.	Log-lik	χ^2	p-value	Log-lik	χ^2	p-value	Log-lik	χ^2	p-value
δ_1	–1455.66	5.16	0.023	–1458.24	0.01	0.919	–1456.41	3.67	0.056
δ_2	–1457.97	0.54	0.461	–1456.29	3.91	0.048	–1456.63	3.22	0.073
δ_3	–1456.86	2.76	0.097	–1457.03	2.42	0.120	–1447.36	21.76	$<$0.001
δ_1, δ_3	–1455.25	5.98	0.050	–1456.96	2.55	0.279	–1442.22	32.04	$<$0.001
δ_1, δ_2	–1455.86	4.75	0.093	–1456.06	4.37	0.112	–1453.65	9.18	0.010
$\delta_1, \delta_2, \delta_3$	–1454.55	7.37	0.061	–1455.15	6.19	0.103	–1441.38	33.71	$<$0.001

Table 3: Tests for the generalization of the mixing distributions for taste intensities.

	Biodyn.-Val Gresta		IPM-Val Gresta		Organic-Val Gresta	
Quantile	Normal	Generalised	Normal	Generalised	Normal	Generalised
2.50%	–4.52	–4.78	–1.31	–1.81	–2.38	–2.37
5%	–3.76	–4.28	–0.98	–1.75	–1.76	–2.05
10%	–2.89	–3.66	–0.60	–1.63	–1.04	–1.62
median	0.19	0.12	0.74	0.36	1.48	1.46
90%	3.28	3.11	2.08	1.56	4.01	3.75
95%	4.15	3.62	2.46	1.56	4.72	4.06
97.50%	4.91	4.06	2.79	1.56	5.34	4.33
mean	0.19	0.58	0.80	0.82	1.48	1.92

Table 4: Comparison of model estimates for *WTP* distributions implied by model 4 (all random taste are normal) and model 5 (VdG has a generalized dsitribution).

Figure 1: Estimated densities for $\hat{\beta}_n$ for VdG origin.



(a) Dashed line generalised density, continuous line normal density.