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Full Research Article

Multi-country stated preferences choice analysis for fresh tomatoes

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Abstract. In this study we investigate consumers' preferences for fresh tomato attributes in four European countries by assessing and comparing Marginal Willingness-To-Pay (MWTP) estimates from panel Mixed Logit (MXL) models with utility specifications in the WTP-space. We performed an in-depth post-estimation inference to identify what attributes are the main determinants of fresh tomato purchases in each domestic market. We also assess the choice probabilities for tomatoes of various origins and types to illustrate how these post-estimation inference can be used to inform strategies designed to increase the market shares of Italian fresh tomato exports in new markets and to consolidate positions in markets where Italian fresh tomatoes are already appreciated by local consumers.

Keywords. Mixed Logit Model, Marginal Willingness-To-Pay, WTP space, preference space, fresh tomato.

JEL Codes. D12, Q13, Q18.

1. Introduction

Fresh tomato is one of the most commonly consumed vegetable in Europe. Over the last decade its consumption has remained stable at about 15 kg/year per capita, although stark changes have been observed concerning the range of quality consumers demand (European Union, 2018).

Italy is one of the major tomato producers in Europe (European Commission, 2020) with exports to German, Austrian, British, French and Romanian markets, where Italian fresh tomatoes are traditionally very appreciated. However, consumers' preferences gradually change, and year after year, the diversity of tomato types sold has increased everywhere to meet a rapidly evolving and diversifying demand. Health, convenience, taste and type of packaging are nowadays some of the most important product values for consumers. In the case of tomatoes, as for other foods, the market for 'specialties' is growing at

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a significant rate (Santeramo et al., 2018). New tomatoes varieties with attractive shapes, colours and tastes, innovative recyclable packaging, health claims and/or environmental certifications have been emerging as valuable product features that producers and retailers use to grow their market shares (Yue and Tong, 2009; Tonsor and Shupp, 2009; Alamanos et al., 2013; Oltman et al., 2014).

Nevertheless, the demand for tomatoes shows substantive differences across countries in terms of favorite shapes, packaging, origins and many other factors. Determining consumers' preferences and Willingness to Pay (WTP) for fresh tomato attributes is important to stakeholders in this industry (e.g., agricultural producers, intermediaries and retailers). It helps them determine which types of fresh tomato to grow and trade, how to manage the marketing mix, what communication content to emphasize in advertising campaigns, and how to apply fair prices along the supply chain. This information is particularly crucial for small-scale farmers who experience a strong competitive pressure from bigger companies of producers and importers. For them it is essential to correctly identify and characterize the market segments to supply, so as to define the assortment of tomatoes to produce the following season.

Against this background, the objective of this study is threefold. Firstly, this study aims at estimating consumers' willingness to pay for fresh tomato attributes across four key importing countries in Europe. Secondly, it aims at identifying the main determinants of tomato purchases across such markets. Thirdly, it aims at exploring how structural estimates of heterogeneous preferences can be used to inform marketing strategies which could guide the growth of Italian fresh tomato exports.

Alongside these research objectives, this paper also aims at achieving methodological and disseminative purposes. It will present and discuss the estimation strategies that could be implemented in a discrete choice cross-sectional analysis to face heterogeneity in preferences and take into account correlations between attributes. Frequently, in discrete choice applications, post estimation analyses are limited to the assessment of the Marginal Willingness-To-Pay (MWTP). But several additional results can be derived by the estimation of a discrete choice model with preference heterogeneity. In order to make concrete the methodological dissemination purposes of this study, the 'Rmarkdown' and 'markstat' codes we used in our analyses are made available to the reader.

The data collection took place in Germany, Russia, the UK and Norway. These countries were selected for different reasons. Two countries, Germany and the UK, are traditional export markets for Italian fresh tomatoes. In particular, Germany has been for several years the main European country for Italian fresh tomatoes exports. In 2015, Germany imported 28,188 tons of Italian fresh tomatoes, equivalent to 31% of the total fresh Italian tomato export. In 2015 the UK ranked third in terms of imported quantity from Italy, with 8,250 tons of fresh tomatoes.[1] The other two countries, Russia and Norway, instead, are marginal markets for Italian fresh tomato producers. Here Italian tomatoes compete with imports from other countries, such as the Netherlands, Spain, Egypt and Morocco. Nevertheless, the four markets under investigation in this study have all, to larger or smaller extent, the potential for future growth of Italian exports if producers will implement strategies aimed at meeting consumers preferences.

[1] Source: Trade Map (http://www.trademap.org).

To achieve the study objectives, the same choice experiment was administered to four representative samples of consumers, one for each country. In the data analysis, to account for heterogeneity in preferences, we used Mixed Logit models (henceforth MXL, see Train, 1998; 1999, 2009) with utility specified in WTP-space, as suggested by Train and Weeks (2005) and Scarpa et al. (2008). Despite the well-argued methodological advantages of this approach, when compared with the more conventional preference-space specification, applications in food choice experiments are still infrequent (Balcombe et al. 2010, Balogh et al. 2016, Caputo et al. 2016, and Caputo et al. 2018). Researchers have generally opted for the more traditional preference-space approach (Loureiro and Umberger, 2007; Ortega et al., 2011; Zanoli et al., 2013; Liu et al., 2019), even to assess the MWTP for tomato attributes (Onozaka and McFadden, 2011; Caputo et al., 2013; Carroll et al., 2013; Maples et al., 2014; Skreli et al., 2017).

In the post-estimation stage of our analysis, estimates of the Marginal Willingness-To-Pay (MWTP) for fresh tomato attributes were derived and compared across the four surveyed countries. From an empirical point of view, MWTPs provide producers with evidence to adjust their price strategy in line with market preferences. Further, we estimated full correlation matrices for random taste coefficients of tomato attributes. We used these to estimate market shares for combinations of tomato shapes and certifications. Signs and magnitudes of significant correlations between random attributes provide crucial information to producers and exporters. They are needed to define product profiles that meet consumers' demand and identify those combinations of tomato traits that consumers dislike. Moreover, to illustrate, probability choice functions were derived for selected product profiles. These functions are useful to predict consumer behavior, since differences in choice probabilities are dependent on tomato attributes. Finally, marginal changes in choice probabilities within samples and for the whole population were simulated. This type of analysis serves as a tool to predict changes in consumer behaviour specific to the different export markets.

The rest of the article is organized as follows. Section 2 discusses materials and method, while Section 3 illustrates the econometric analysis. Section 4 reports and discusses results. We conclude with some final remarks in Section 5.

2. Materials and method

Data used for this analysis were collected through a choice experiment designed to gather statements on hypothetical purchases of fresh tomato by consumers living in Germany, Russia, the UK and Norway. Preliminary focus groups and pilot surveys supported the final design of the questionnaire. Tomato attributes and levels were identified from previous studies (Yue and Tong, 2009; Onozaka and McFadden, 2011; Caputo et al., 2013; Carroll et al., 2013; Maple et al., 2014; Oltman et al., 2014; Meyerding, 2016; Skreli et al., 2017) and via discussion with experts in these export markets. Ten attributes were selected to profile fresh tomato characteristics. These were: tomato shape (which acts as a label for the product alternatives), colour, skin thickness, pulp type, packaging format, country of origin, production method, workers' health and safety certification[2], eco-sustainability

[2] In the questionnaire this attribute was explained as follows: "*tomatoes can be produced according to systems that ensure high health and safety standards to workers. The final product can have a label that certifies that these standards were implemented in production*".

Table 1. Attributes and levels.

Attribute	Attribute levels
Shape	**beef**, salad (*Salad*), vine (*Vine*), cherry (*Cherry*), date (*Date*)
Colour	red (*Red*), **not-red** (i.e., yellow, orange or variegated)
Skin	**thin**, thick (*Thick*)
Pulp	**juicy**, rich (*Rich*)
Packaging	**loose tomatoes**, net (*Net*), tray (*Tray*)
Origin	**Italy**, Netherlands (*NLD*), Spain (*ESP*), Morocco (*MAR*), Egypt (*EGY*), others (*OTH*)
Production method	**conventional**, low environmental impact (*Env*), organic (*Org*)
Workers' health and safety certified	**not present**, present (*Safety*)
Eco-sustainable certified	**not present**, present (*Eco*)
Price (euro/kg)	1.18, 1.58, 2.37, 2.76

Note: qualitative attributes were coded using dummy variables. The price attribute was coded using a continuous variable. In **bold** font the reference level. In brackets the variable name.

certification of production methods (including organic)[3] and price[4]. Table 1 reports the attributes and their levels.

To generate the alternatives, we used a fraction of the full factorial design, that was *D*-error minimizing within the sets that are orthogonal in the difference (refer to NGENE handbook for details). By using NGENE 12.0, 144 choice tasks were generated, blocked in twelve blocks of twelve each. Respondents were randomly assigned in a balanced rotation to one of the twelve blocks. Each was asked to complete the twelve randomized choice tasks in their assigned block. Given the complexity of the experimental design, the qualitative attribute named 'colour' was not directly included in the experimental design but was paired with tomato shape. Consequently, the combination between shape and colour was constant in each block, but combinations changed between blocks and assigned to different people. In this way, each respondent always visualized the same pictures for the five tomato alternatives in all choice scenarios under his/her scrutiny. The other attributes were presented in a textual form. Figure 1 illustrates a choice card.

The final questionnaire contained three sections. The first was designed to identify the respondent's socio-demographic profile; the second relates to food consumption habits, with specific reference to fresh tomatoes; the final section was dedicated to the choice experiment.

The survey was carried out in April 2016. The target population consisted of adult consumers that consumed fresh tomatoes in the last six months and were aware about the product characteristics. Country samples were selected to be representative of national populations in terms of age and gender. Interviews were conducted online and administered by Toluna (www.it.toluna.com), a market research company that deals with market

[3] In the questionnaire this attribute was explained as follows: "*tomatoes can be produced according to systems that ensure ecological sustainability and biodiversity protection. The final product can have a label that certifies that these standards were implemented in production*".

[4] In the questionnaire, prices were expressed in the national currency.

Figure 1. Example of a choice card.

Workers' health and safety certification	No	No	Yes	No	No
Packaging	Loose tomatoes	Net	Loose tomatoes	Loose tomatoes	Net
Eco-sustainable certified	Yes	No	No	Yes	Yes
Pulp	Juicy	Juicy	Juicy	Rich	Juicy
Production method	Low env. Impact	Organic	Low env. impact	Conventional	Organic
Skin	Thick	Thin	Thin	Thick	Thin
Origin	Morocco	Italy	Morocco	Netherlands	Netherlands
Price (€/kg)	2.76	2.37	1.58	1.18	1.58

analysis and has a world opt-in panel with over 9 million consumers. The company supplied the availability of high-quality Internet panels (i.e., ISO certification and application of international quality standards for market research) and guaranteed an incidence rate equal to 0.70 for each country.

The online questionnaire was completed by a total number of 2,600 respondents: 700 in Germany, Russia and the UK and 500 in Norway. The total choice observations generated were 31,200 (12 choice cards for 2,600 respondents). The number of products evaluated by respondents amounted to 156,000 (5 tomato shapes/scenarios for 2,600 respondents).

Table 2 reports the summary statistics at country level and for the whole sample.

Table 2. Summary statistics.

	Germany (n = 700)		Norway (n = 500)		Russia (n = 700)		UK (n = 700)		All (n = 2,600)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
White European ethnicity*	0.89	0.31	0.81	0.40	0.95	0.22	0.81	0.39	0.87	0.34
BMI	25.42	5.68	25.50	5.05	24.72	6.86	26.00	6.53	25.40	6.16
Vegetarian/vegan *	0.09	0.29	0.07	0.26	0.10	0.31	0.10	0.31	0.10	0.29
Female*	0.60	0.49	0.53	0.50	0.60	0.49	0.60	0.49	0.59	0.49
Age (in year)	39.01	12.09	40.34	16.74	38.70	11.09	39.23	12.40	39.24	12.96
Education**	0.29	0.45	0.39	0.49	0.75	0.43	0.43	0.50	0.47	0.50
Family size (n.)	2.54	1.23	2.47	1.39	3.23	1.17	2.84	1.34	2.79	1.31
Minor or dependent (n.)	0.68	0.92	0.61	1.02	0.93	0.94	0.79	1.04	0.77	0.99

*1 if yes; ** 1 if university graduate or post graduate.

3. Econometric model and inference

The choice data were analyzed by means of econometric models based on random utility maximization with heterogenous preference parameters (McFadden, 2001).

We assumed a linear and additive indirect utility function:

$$U_{njt}=-\alpha_n p_{njt}+\boldsymbol{\beta}_n^{'}\mathbf{x}_{njt}+\varepsilon_{njt} \tag{1}$$

where p_{njt} is the price attribute, $\mathbf{x}_{njt}$ represents the vector of non-price tomato attributes, and α_n and $\boldsymbol{\beta}_n$ are random parameters which represent n^{th} respondent's taste intensities for each attribute describing the tomato profile of each j^{th} alternative in the t^{th} choice occasion in the sequence. For the random component, we hypothesized that $\varepsilon_{njt}\sim$ i.i.d. Gumbel. Assumptions imply that, conditional on $\boldsymbol{\beta}_n$, the probability of observing a particular sequence of 12 choices for each n^{th} respondent ($y_n=y_{n1},y_{n2},\ldots,y_{n12}$) is the product of standard logit formulas:

$$L(y_{n1},y_{n2},\ldots,y_{n12}\,|\alpha_n,\boldsymbol{\beta}_n)=\prod_{t=1}^{12}\frac{\exp(-\alpha_n p_{nit}+\boldsymbol{\beta}_n'\mathbf{x}_{nit})}{\sum_{j=1}^{5}\exp(-\alpha_n p_{njt}+\boldsymbol{\beta}_n'\mathbf{x}_{njt})} \tag{2}$$

Unconditional probability was calculated as the integral of equation (2) weighted by the density function $g(\alpha_n,\boldsymbol{\beta}_n|\boldsymbol{\mu},\boldsymbol{\Omega})$:

$$P_n(y_n)=\int L(y_{n1},y_{n2},\ldots,y_{n12}|\alpha_n,\boldsymbol{\beta}_n)g(\alpha_n,\boldsymbol{\beta}_n|\boldsymbol{\mu},\boldsymbol{\Omega})d\alpha_n d\boldsymbol{\beta}_n \tag{3}$$

This integral was approximated through simulation, by: *i*) taking draws from the *g*(.) function; *ii*) calculating the Likelihood function for each draw; and *iii*) averaging the results. The maximum simulated likelihood estimator is the value of the unknown parameters that maximizes the likelihood of the sample simulated in this manner.

Equation (3) represents the so-called panel mixed logit, which allowed us to use a mixed logit model specification in the context of repeated choices by respondents assuming specific taste distributions (Revelt and Train, 1998). To obtain a posterior distribution of $\alpha_n,\boldsymbol{\beta}_n$ for each respondent, the procedure described by Revelt and Train (2000) can be used.

Following Train and Weeks (2005) we specified the utility function in the *WTP space*[5]. With a Gumbel distributed unobservable component of utility, the error variance varies among respondents:

$$Var(\varepsilon_{njt})=k_n^2\left(\pi^2/_6\right) \tag{4}$$

where k_n represents a scale parameter for the n^{th} respondent. To allow for random scale parameter, Train and Weeks (2005) suggested to divide equation (1) by the scale parameter:

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[5] Sonnier et al. (2007) called this model the "consumer's surplus model". It is also known in literature as "expenditure function space" model, "valuation function", or "money-space" (Thiene and Scarpa, 2009).

$$U_{njt} = -\left(\alpha_n / k_n\right) p_{njt} + \left(\boldsymbol{\beta}_n / k_n\right)' \mathbf{x}_{njt} + u_{njt} \quad (5)$$

As a consequence, in equation (5), u_{njt}~i.i.d. Gumbel, but with constant variance equal to $\pi^2/6$. Assuming that $\lambda_n=a_n/k_n$ and $\boldsymbol{c}_n=\boldsymbol{\beta}_n/k_n$, equation (5) becomes:

$$U_{njt}=-\lambda_n p_{njt}+\boldsymbol{c}_n'\mathbf{x}_{njt}+u_{njt} \quad (6)$$

where $\lambda_n=a_n/k_n$, $\boldsymbol{w}_n = \boldsymbol{c}'_n/\lambda_n$, $\boldsymbol{c}_n=\boldsymbol{\beta}_n/k_n$ and k_n represents the scale parameter for the n^{th} respondent.

Equation (6) is the so-called utility function in the *preference space*. Given that, by definition, the MWTP for an attribute is the ratio between the attribute's coefficient and the coefficient of the price attribute, equation (6) can be re-written as follows:

$$U_{njt}=-\lambda_n p_{njt}+(\lambda_n \boldsymbol{w}_n)'\mathbf{x}_{njt}+u_{njt} \quad (7)$$

where $\boldsymbol{w}_n = \boldsymbol{c}'_n/\lambda_n$. Equation (7) is the so-called utility function in *WTP space* (Train and Weeks, 2005).[6]

Through the direct choice of specific random WTP distributions, the WTP space approach prevents situations where the implied MWTP distributions from the random preference coefficients show excessively long tails. This is often the case in preference-space utility specifications (Scarpa et al., 2008). The literature reports controversial results on what approach produces a better fit to the empirical data. However, there is a general consensus on the ability of WTP space specifications to generate more reasonable and less disperse estimates of WTP distributions (Scarpa et al., 2008; Balcombe et al., 2009; Hensher an Greene, 2009; Rose and Masiero, 2009; Daly et al 2012; Owusu Coffie et al., 2016).

Our estimator was implemented in STATA 15.0 and employed the packages mixlogitwtp (Hole, 2007). We did not find significant evidence of heterogeneity in preliminary estimations for tomato colour, skin, pulp and country of origin. So, we assumed these to be fixed, meaning that we hypothesized homogeneous preferences for these features. Conversely, we obtained significant variance estimates in preliminary results for tomato shapes, packaging types and certifications. Hence, the associated random parameters were consequently assumed to be random and specifically distributed multi-variate normal with a full correlation matrix. The coefficient for the negative of price was assumed to have a log-normal distribution, to constrain the price coefficient to be always negative. Estimates were obtained with 1,000 Halton draws, which despite the high number of random parameters, can assure sufficiently low simulation variance of the maximum simulated likelihood estimator according to Zeng (2016) and Palma et al. (2018).

While all of the above is informative, it is also quite standard. In this study, however, we extended the range of inference in a more novel direction. We used the estimates of the vector of means $\boldsymbol{\mu}$ and their variance-covariance matrix $\boldsymbol{\Omega}$=(**LL**') for each country to infer the probabilistic choice behavior in the underlying population of consumers. Note

[6] Sonnier et al. (2007) called this model the "consumer's surplus model". It is also known in literature as "expenditure function space" model, "valuation function", or "money-space" (Thiene and Scarpa, 2009).

that estimates of the Cholesky decomposition $\mathbf{L}$ of the full variance-covariance matrix $\boldsymbol{\Omega}$ enabled us to derive the correlation matrix for the random α and $\boldsymbol{\beta}$. With this we identified patterns of covariation across taste parameters $\boldsymbol{\beta}$ that we then used in behavioral inference. For example, we used them in the derivation of probabilistic demand functions based on the simulation of distributions of preference values $\boldsymbol{\beta}$ in the population from which to infer market choice probabilities. We replicated this for selected tomato attributes (tomato profiles) and compared them across countries.

Another type of inference was conducted at the sample level. Here information on the observed choice sequence of each respondent was brought to bear by deriving individual specific means $\overline{\boldsymbol{\beta}}_n$ for marginal WTPs. These are graphically represented for the samples by kernel smoothing plots for the sample of each country. Hypothetical choice probabilities were also simulated at the population estimates by modifying the choice sets to evaluate shares for what-if scenarios. Scenarios simulated the introduction in the choice tasks of specific tomatoes profiles at a given price. We provide an illustration of the latter obtained with the post estimation commands in Stata. This required the modification of one or more attribute levels in the choice set and the re-computation of the in-sample predicted probabilities of choice to obtain changes in market shares following the introduction of new tomato profiles.

4. Results and discussion

Table 3 reports the coefficients estimates for each country. The model estimated for the pooled samples across countries are reported in the last columns to the right. The uninformed sequence of 12 choices between 5 alternatives has a log-likelihood of $\ln[(1/5)^{12}]=-19.31$, while the averages in our estimated model range between a maximum of -16.33 and a minimum of -16.67, respectively 0.85 and 0.86 percent of the uninformed probability. This implies a good explanatory power of the joint model.

Findings suggest that red color (baseline yellow/orange/variegated) and country of origin (baseline Italy) are key determinants of choice, while a thick tomato peel (baseline thin) and a rich pulp (baseline juicy) do not seem to be relevant. Preferences vary across the investigated markets, especially for the country of origin. Italian tomatoes are always preferred to those coming from other origins for Germans. These, for example, are willing to pay an average premium of 0.90 €/kg for Italian tomatoes in comparison to those coming from Morocco. Russians are generally indifferent to country of origin when tomatoes come from Egypt, Italy or Spain. However, they significantly dislike those produced in the Netherlands, Morocco or "other countries". For the latter, WTP is comparatively lower by about 0.19-0.21 €/kg. The UK consumers emerged as "origin-blind" as the country of origin never emerges as significant.

Country-level models' results further suggest that Norwegians appreciate juicy tomatoes (+ 0.15 €/kg in comparison to rich-pulp tomatoes), while Russians prefer to buy thin-skin tomatoes (+ 0.23 €/kg in comparison to thick-skin ones).

Interestingly, preferences for tomato shapes vary across countries and, at the same time, are also significantly heterogeneous within each country. For the coefficients of tomato shapes, standard deviations are significantly different from zero, with the exception of "cherry" and "date" shaped tomatoes in the UK and "date" shaped tomato in Nor-

Table 3. Mixed logit models' coefficients estimates.

Variables	Germany		Norway		Russia		UK		All	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Red	3.77 *** (12.87)		2.26 *** (15.70)		1.39 *** (23.26)		3.95 *** (13.69)		2.52 *** (31.02)	
Thick	0.05 (0.56)		0.01 (0.12)		-0.23 *** (5.79)		-0.03 (0.35)		-0.06 (1.86)	
Rich	-0.07 (0.85)		-0.15 * (2.57)		0.05 (1.39)		-0.09 (1.17)		-0.03 (0.91)	
NLD	-0.39 ** (2.64)		-0.09 (0.93)		-0.19 ** (2.92)		-0.01 (0.10)		-0.18 ** (3.41)	
ESP	-0.65 *** (4.28)		-0.15 (1.43)		-0.12 (1.89)		0.09 (0.63)		-0.21 *** (3.94)	
MAR	-0.90 *** (5.50)		-0.19 (1.89)		-0.21 ** (3.15)		0.01 (0.06)		-0.29 *** (5.44)	
EGY	-0.86 *** (5.15)		-0.16 (1.51)		-0.09 (1.38)		-0.05 (0.39)		-0.25 *** (4.64)	
OTH	-0.62 *** (4.00)		-0.23 * (2.31)		-0.19 ** (2.87)		-0.27 (1.90)		-0.29 *** (5.34)	
Salad	-2.70 *** (10.29)	2.05 *** (8.80)	-1.35 *** (10.05)	1.17 *** (8.81)	-0.20 ** (2.78)	0.75 *** (10.12)	-2.36 *** (9.20)	2.48 *** (9.49)	-1.45 *** (18.64)	1.43 *** (18.20)
Vine	1.11 *** (7.58)	0.54 ** (3.47)	0.68 *** (6.41)	0.50 *** (5.30)	0.57 *** (9.21)	0.48 *** (9.45)	1.57 *** (8.56)	1.16 *** (7.58)	0.73 *** (14.76)	0.18 * (2.12)
Cherry	-2.00 *** (7.89)	1.81 *** (7.96)	-0.82 *** (6.46)	0.80 *** (6.48)	-0.95 *** (11.00)	0.41 *** (3.96)	-0.68 *** (4.47)	0.21 (1.17)	-1.12 *** (14.56)	0.52 ** (2.63)
Date	-3.62 *** (9.95)	0.83 ** (2.92)	-1.13 *** (7.57)	0.10 (0.77)	-1.21 *** (10.53)	0.71 *** (5.15)	-1.80 *** (7.81)	0.02 (0.14)	-1.75 *** (18.41)	0.07 (0.52)
Net	-0.25 * (1.97)	0.26 (0.76)	-0.10 (1.04)	0.38 * (2.37)	-0.14 * (2.08)	0.05 (0.53)	-0.10 (0.79)	0.53 (2.64)	-0.16 ** (3.38)	0.02 (0.21)
Tray	-0.72 *** (5.23)	0.34 (1.80)	-0.45 *** (4.66)	0.32 * (2.34)	-0.05 (0.80)	0.06 (0.81)	-0.64 *** (4.63)	0.05 (0.31)	-0.39 *** (7.83)	0.03 (0.41)
Env	0.18 (1.24)	0.25 (0.80)	-0.05 (0.50)	0.02 (0.14)	-0.22 ** (2.95)	0.38 *** (4.43)	0.23 (1.75)	0.15 (0.69)	0.01 (0.22)	0.08 (0.81)
Org	1.22 *** (6.23)	0.99 *** (4.23)	0.26 * (2.32)	0.80 *** (6.03)	-0.07 (0.93)	0.17 (1.90)	0.39 ** (2.65)	0.24 (1.02)	0.37 *** (6.58)	0.56 *** (3.73)
Safety	0.56 *** (4.81)	0.04 (0.17)	0.50 *** (5.36)	0.23 (1.66)	0.23 *** (3.85)	0.33 ** (3.28)	0.79 *** (6.26)	0.19 (0.97)	0.43 *** (10.12)	0.13 (0.81)
Eco	0.60 *** (4.69)	0.06 (0.30)	0.16 (1.82)	0.03 (0.25)	0.37 *** (5.56)	0.36 *** (3.85)	0.47 *** (3.98)	0.31 (1.49)	0.44 *** (9.36)	0.20 (1.94)
Ln-neg.p	-1.21 *** (15.69)	0.13 * (1.99)	-0.68 *** (11.21)	0.10 (0.83)	-0.48 *** (10.06)	0.04 (0.41)	-1.19 *** (16.06)	0.01 (0.19)	-0.85 *** (27.52)	0.17 ** (2.94)
Choices	42,000		30,000		42,000		42,000		156,000	
N	700		500		700		700		2,600	
ln-L/N	-16.335		-16.429		-16.488		-16.488		-16.674	
AIC	23,039.51		16,598.87		23,252.95		23,253.01		86,875.59	
BIC	23,774.37		17,305.14		23,987.81		23,987.87		87,721.99	

*p<0.05; **p<0.01; *** p<0.001. *z* statistic in parenthesis. Variables coding is reported in Table 1.

way. “Vine” tomatoes are always preferred to “beef” (the baseline) across all countries, while the latter are always preferred to “salad”, “cherry” and “date” tomatoes.

In general, consumers prefer to buy loose (the baseline) rather than packaged tomatoes. However, preferences for packaging types (in “nets” or “tray”) are not always significant and emerge as heterogenous at the country level.

Tomatoes with certified credence attributes are preferred to those without certification. In particular, Germans are willing to pay, on average, 1.22 €/kg for organic-certified tomatoes, even if the distribution is strongly dispersed in comparison to those in other countries. German consumers are also sensitive to certifications ensuring workers’ health and safety (+ 0.56 €/kg) and eco-sustainability (+ 0.60€/kg). However, the choices observed in the UK sample imply a higher willingness to pay for workers’ health and safety certification (+ 0.79 €/kg).

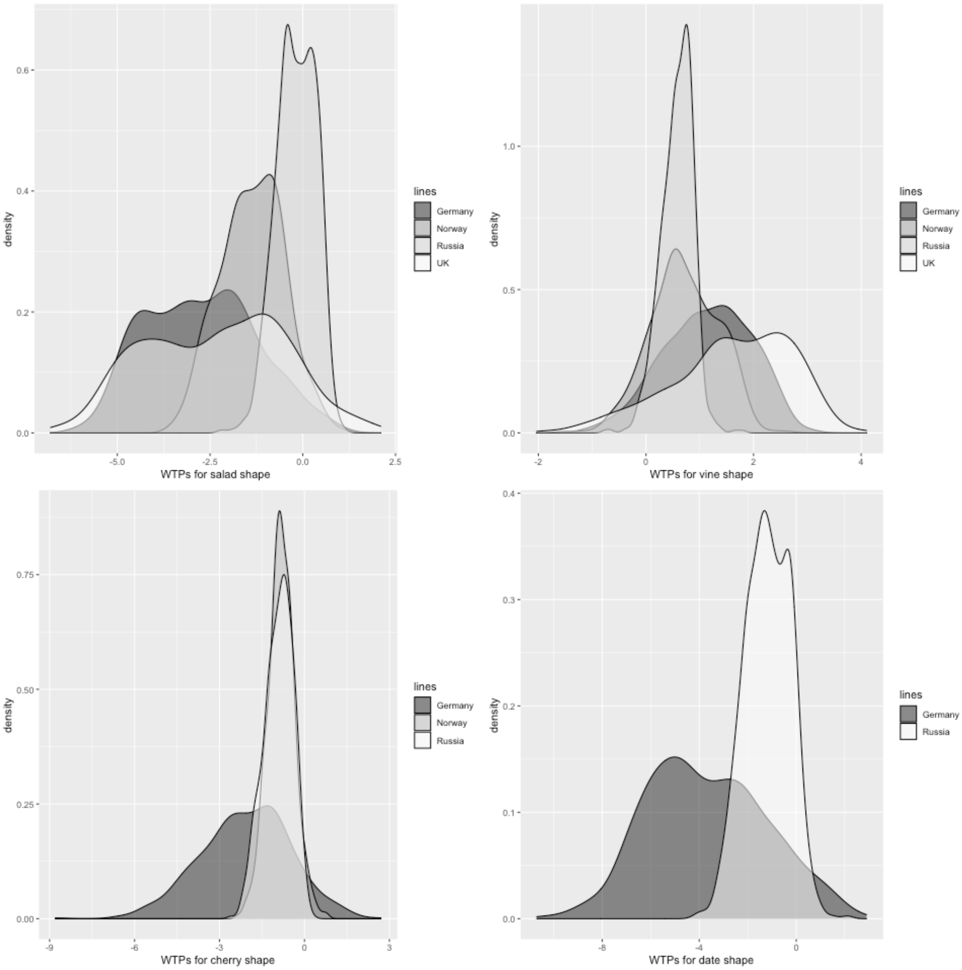
Preferences for certifications show a significant heterogeneity for organic products in Germany and Norway. Russians demonstrated significant heterogeneous preferences for low-environmental impact, workers’ health and safety, and eco-sustainable certified products. Instead, organic certification is not appreciated by Russians, who in turn are the only consumers with a significant positive appreciation for certification for low-environmental impact production methods.

Figure 2 displays the kernel smoothing of individual posterior means of MWTP sample distributions for each country for tomato shape, whose coefficients showed a significant heterogeneity in the majority of the investigated countries. Sample distributions are displayed only for those tomato shapes which have both significant mean and standard deviation estimates. Some distributions differ significant in terms of range, number of modes and relative positions in the WTP space. As pointed out earlier, German and UK consumers do not appreciate salad tomatoes in comparison to beef ones. Their MWTP distributions are prevalently located in the negative range and are multimodal in both cases. This implies that, everything else equal, for most consumers, salad tomatoes need to be sold at a lower target price compared to beef tomatoes to induce a purchase; how much lower is different in the two countries.

In contrast, MWTP for salad tomatoes in the other two markets are located to the right, especially for Russia, that present both positive and negative modal values. Negative means of MWTP are shown also for cherry and date tomatoes in comparison to beef tomatoes. However, preferences for cherry tomatoes seem to be more similar among Norwegian and Russian consumers than Germans; while MWTP distribution for date tomatoes are less dispersed for Russians and more variable for Germans. Vine tomatoes, in contrast, are preferred to beef ones in all markets. Modal value estimates are always positive, although the ranges of variation are extremely different between countries, with the widest one in the UK, where there is also the higher modal value.

Table 4 reports the estimates of correlation coefficients (lower triangle), variances (diagonal) and covariances (upper triangle) between random MWTPs in each country. For some pairs of random attributes, correlations are significant across all models and have concordant signs, even if they have different magnitude. Correlations between salad and date tomatoes, for instance, are always positive and significant in all markets, meaning that these kinds of tomato could be jointly sold in these countries through focussed advertising strategies exploiting the “drag” effect of a tomato type on the other. Converse-

Figure 2. Kernel density plots for conditional WTPs for tomato shapes.



ly, a negative correlation is estimated between salad and vine-shaped tomatoes. For Germany and Norway, in particular, the correlation coefficients are high and significant, -0.89 and -0.84 respectively. This finding is focal to support product marketing by the sellers: salad and vine tomatoes are antagonist in these markets and meet the preferences of different consumers and consequently separate market targets. This could suggest locating these products on different shelves or even separate shops when the locations of these are correlated with one type of buyers. Country-level preferences for type of packaging vary and they are correlated with the tomato's shape. In general, all consumers prefer to buy loose-packaged tomatos. However, Germans prefer to buy salad tomatoes that are tray-packaged (correlation coefficients: 0.77) and dislike trays for vine ones (-0.85); Norwegians like cherry tomatoes when packaged in a net (0.79). For the UK and Russia, some

Table 4. Estimates of correlation and covariance matrixes in each country.

Germany	Salad	Vine	Cherry	Date	Net	Tray	Env	Org	Safety	Eco	Np
Salad	**4.20**	**-2.19**	-0.38	**4.58**	0.47	**1.25**	0.14	0.46	**-0.58**	-0.14	0.06
Vine	***-0.89***	**1.44**	**1.05**	**-1.23**	-0.34	**-0.81**	-0.15	0.30	**0.46**	0.18	**-0.15**
Cherry	*-0.08*	***0.37***	**5.77**	**4.82**	0.10	-0.14	0.24	**-1.09**	**0.62**	-0.27	0.17
Date	***0.66***	***-0.30***	***0.60***	**11.30**	0.74	0.94	-0.30	-0.05	-0.08	-0.58	-0.15
Net	*0.38*	*-0.46*	*0.07*	*0.36*	0.38	0.19	-0.29	**-1.17**	-0.14	**-0.36**	0.10
Tray	***0.77***	***-0.85***	*-0.07*	*0.35*	*0.40*	**0.63**	0.29	-0.56	-0.12	-0.08	**0.20**
Env	*0.07*	*-0.13*	*0.11*	*-0.10*	*-0.50*	*0.39*	**0.86**	0.58	0.08	0.23	0.17
Org	*0.09*	*0.09*	***-0.17***	*-0.01*	***-0.72***	*-0.27*	*0.24*	**6.98**	-0.35	0.58	**-0.37**
Safety	***-0.37***	***0.50***	***0.34***	*-0.03*	*-0.29*	*-0.19*	*0.11*	*-0.10*	**0.59**	**0.61**	-0.05
Eco	*-0.06*	*0.13*	*-0.09*	*-0.15*	*-0.51*	*-0.09*	*0.21*	*0.26*	*0.68*	1.37	-0.21
-Price	*0.05*	***-0.22***	*0.12*	*-0.07*	*0.28*	***0.42***	*0.32*	***-0.08***	*-0.12*	***-0.31***	**0.34**

Norway	Salad	Vine	Cherry	Date	Net	Tray	Env	Org	Safety	Eco	Np
Salad	**1.37**	**-0.93**	-0.21	**1.21**	-0.14	0.14	-0.08	0.24	-0.13	0.07	0.07
Vine	***-0.84***	**0.88**	0.21	**-0.40**	0.16	-0.05	-0.08	**-0.33**	0.04	-0.16	**-0.23**
Cherry	*-0.21*	*0.27*	**0.69**	**0.43**	**0.41**	0.03	0.00	-0.06	-0.09	-0.06	0.04
Date	***0.71***	***-0.29***	***0.35***	**2.14**	0.26	0.23	-0.26	-0.01	**-0.34**	-0.16	-0.16
Net	*-0.19*	*0.26*	***0.79***	*0.29*	**0.39**	0.08	-0.01	0.00	0.19	-0.01	-0.06
Tray	*0.30*	*-0.13*	*0.08*	*0.39*	*0.33*	0.16	0.01	0.09	-0.07	0.01	0.01
Env	*-0.20*	*-0.24*	*0.02*	*-0.48*	*-0.05*	*0.06*	0.14	0.16	-0.11	0.01	**0.11**
Org	*0.20*	*-0.35*	*-0.07*	*-0.01*	*0.01*	*0.21*	*0.43*	**1.02**	0.03	**0.36**	0.10
Safety	*-0.12*	*0.05*	*-0.11*	***-0.24***	*0.31*	*-0.17*	*-0.31*	*0.03*	**0.93**	**0.27**	**-0.16**
Eco	*0.08*	*-0.24*	*-0.10*	*-0.15*	*-0.02*	*0.03*	*0.05*	***0.25***	***0.41***	**0.49**	0.01
-Price	*0.12*	***-0.46***	*0.09*	*-0.20*	*-0.17*	*0.07*	***0.54***	*0.05*	***-0.31***	*0.02*	**0.29**

Russia	Salad	Vine	Cherry	Date	Net	Tray	Env	Org	Safety	Eco	Np
Salad	**0.57**	-0.08	0.12	**0.71**	-0.09	**0.20**	0.09	-0.06	**-0.17**	**-0.12**	**-0.24**
Vine	*-0.23*	**0.24**	**0.28**	**0.25**	0.02	-0.02	-0.02	-0.06	-0.01	-0.01	**-0.17**
Cherry	*0.21*	***0.75***	**0.60**	**0.51**	-0.10	-0.08	-0.07	**-0.26**	-0.06	0.09	**-0.44**
Date	***0.67***	***0.35***	***0.47***	**1.98**	**-0.22**	**0.21**	0.14	-0.10	**-0.26**	-0.14	**-0.39**
Net	*-0.33*	*0.14*	*-0.36*	***-0.42***	**0.14**	0.10	0.05	**0.10**	0.00	**-0.14**	0.06
Tray	***0.53***	*-0.10*	*-0.22*	***0.29***	*0.55*	**0.25**	**0.14**	0.08	**-0.14**	**-0.28**	0.05
Env	*0.23*	*-0.09*	*-0.17*	*0.19*	*0.23*	*0.54*	0.28	0.16	-0.02	**-0.16**	0.14
Org	*-0.13*	*-0.19*	***-0.54***	*-0.11*	***0.43***	*0.24*	***0.48***	**0.40**	0.09	-0.05	0.12
Safety	***-0.36***	*-0.03*	*-0.13*	***-0.31***	*0.00*	***-0.45***	*-0.07*	*0.09*	**0.38**	**0.26**	0.03
Eco	***-0.21***	*-0.03*	*0.15*	*-0.13*	***-0.49***	***-0.73***	***-0.40***	*-0.07*	***0.55***	**0.58**	**-0.14**
-Price	***-0.39***	***-0.42***	***-0.71***	***-0.34***	*0.21*	*0.12*	***0.32***	*0.16*	*0.06*	***-0.23***	**0.64**

	UK										
	Salad	Vine	Cherry	Date	Net	Tray	Env	Org	Safety	Eco	Np
Salad	**6.14**	**-2.66**	**-0.69**	**5.70**	0.43	**0.92**	-0.30	-0.02	-0.58	-0.50	0.12
Vine	***-0.68***	**2.50**	-0.16	**-2.63**	-0.25	**-0.63**	**0.47**	**0.51**	0.29	0.04	**-0.62**
Cherry	***-0.53***	*-0.19*	0.27	-0.50	-0.04	-0.09	0.00	-0.15	0.11	0.14	0.14
Date	***0.98***	***-0.71***	*-0.41*	**5.48**	0.38	**0.73**	-0.16	-0.03	-0.42	-0.39	0.09
Net	*0.25*	*-0.23*	*-0.11*	*0.24*	**0.47**	**0.35**	0.10	-0.27	**-0.29**	**-0.41**	0.14
Tray	***0.49***	***-0.53***	*-0.23*	***0.41***	***0.68***	**0.58**	-0.04	-0.32	**-0.29**	**-0.40**	**0.28**
Env	*-0.18*	***0.44***	*0.01*	*-0.10*	*0.22*	*-0.07*	0.46	0.14	0.06	-0.22	**-0.15**
Org	*-0.01*	***0.28***	*-0.25*	*-0.01*	*-0.35*	*-0.38*	*0.19*	**1.28**	-0.07	0.26	**-0.20**
Safety	*-0.24*	*0.19*	*0.22*	*-0.18*	***-0.44***	***-0.39***	*0.09*	*-0.06*	**0.94**	**0.53**	-0.15
Eco	*-0.22*	*0.03*	*0.29*	*-0.18*	***-0.65***	***-0.57***	*-0.35*	*0.21*	***0.59***	**0.86**	**-0.15**
-Price	*0.08*	***-0.66***	*0.44*	*0.07*	*0.33*	***0.61***	***-0.37***	***-0.11***	*-0.26*	***-0.26***	**0.36**

Note: estimates of variances are reported in the diagonal. Covariance and correlation estimates are reported above and below the diagonal, respectively. Correlations are in *italic*. In **bold** the estimates which are significant with $p<0.05$.

estimates of correlation coefficients between tomato shapes and package types are significant, but their values are lower than 0.60, showing a low-to-moderate correlation.

Another interesting result concerns the relationship between certifications of workers' health and safety protection and eco-sustainability. Their correlation is always significant and positive, suggesting that consumers who are willing to pay for an eco-sustainable tomato are also willing to pay for a health and safety-certified tomato. However, the correlation coefficients are moderate ranging between 0.41 (for Norway) and 0.68 (for Germany).

Table 5 reports estimates of the market shares for combinations of tomato shape and certifications. In all investigated markets, vine tomato shows the higher shares. In all countries, this tomato type could increase its market share when certified as produced with methods that promote workers' health and safety, or eco-sustainability.

Figure 3 displays the estimated choice probability functions for selected product profiles along the price/kg dimension, when the baseline is a beef tomato without any additional attribute. For all graphs we adopted a price ranging from the lower level assumed in the choice experiment (1.81 €/kg) to three times the higher level (3 x 2.76 €/kg).

The top left plots of figure 3 show that as price increases the predicted purchase probability by Germans of red rich-pulp Italian tomatoes drops rapidly, so that at a price of 6€/kg it is basically zero except for vine tomato sold loose and certified.

The function for Norway investigates the simulated effects of eco-sustainable and organic certification of red Italian tomatoes, while the function for Russia is about the effect of tomato shape. Finally, the function for the UK investigates the role of certification for the same tomato profile and demonstrates that in this country consumers have the same reactions to price changes regardless the type of certification.

Figure 4 focuses on co-variation of preferences for tomato shapes, specifically salad and date, both of which tends to be disliked compared to the beef tomato baseline. It reports the iso-quantile plots for all the countries of bivariate kernel densities of MWTP

Table 5. Market shares for combinations of tomato shapes and certifications.

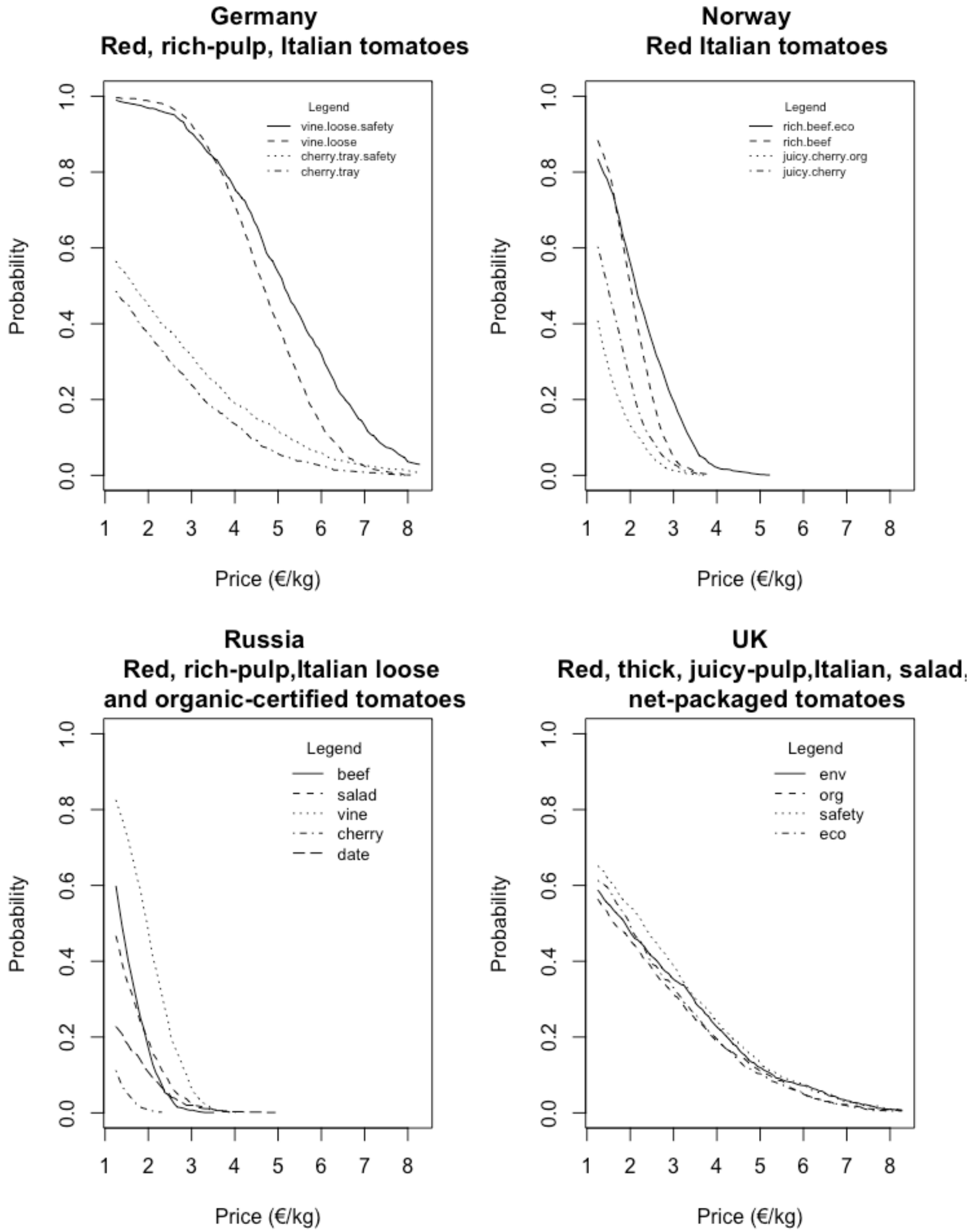
Shape	Certifications	Germany	Norway	Russia	UK
Salad	org-safety	4%	6%	11%	7%
	org-safety-eco	4%	4%	8%	5%
	org-eco	6%	6%	10%	7%
	safety-eco	5%	5%	17%	8%
	env-safety	4%	2%	10%	7%
	env-safety-eco	3%	1%	7%	4%
Vine	org-safety	45%	29%	28%	45%
	org-safety-eco	37%	22%	21%	36%
	org-eco	41%	28%	25%	40%
	safety-eco	54%	32%	46%	54%
	env-safety	39%	17%	20%	48%
	env-safety-eco	32%	11%	14%	34%
Cherry	org-safety	11%	5%	0%	4%
	org-safety-eco	8%	3%	0%	3%
	org-eco	8%	6%	1%	4%
	safety-eco	12%	5%	6%	8%
	env-safety	12%	3%	1%	6%
	env-safety-eco	8%	2%	1%	5%
Date	org-safety	7%	8%	5%	10%
	org-safety-eco	6%	6%	3%	7%
	org-eco	6%	8%	5%	9%
	safety-eco	8%	7%	8%	11%
	env-safety	6%	2%	5%	10%
	env-safety-eco	4%	2%	3%	6%

estimates in a range of change between -5 to +5 Euro/kg compared to the baseline product profile. The price change combinations along each iso-quantile curve represent the proportion of the population with the same probability of selecting tomatoes with one of the two shapes rather than the baseline beef tomato.

The isoquantiles highlight a positive correlation between salad and date-shaped tomatoes in the four countries, but the price set combinations with which they relate to the baseline are quite different. For German consumers, with a correlation estimate of 0.66, the curves cover a much larger set of MWTP values than in the Russian and Norwegian samples. For the UK consumers, the MWTP ranges are similar to those shown in Germany. However, because of the much stronger correlation of 0.98 between the shape attributes, the room for a differentiated pricing policy is much reduced. Norwegian and Russian consumers show quite similarly sets in terms of preferences and willingness to pay.

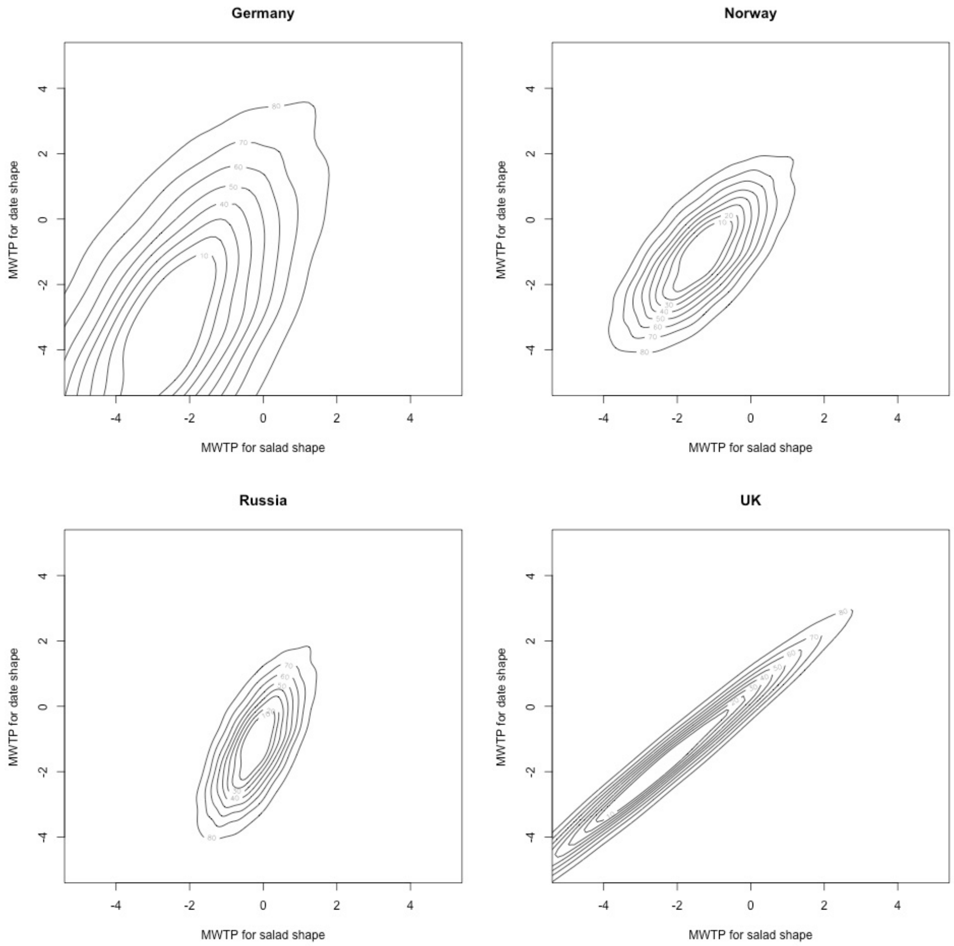
Finally, the estimated models can be used to simulate marginal changes in probability of choice within the samples rather than in the population. For example, what would the distribution of choice probability be, within the German sample, if all choice tasks including the baseline Italian tomato were offered with certification for workers' health and safe-

Figure 3. Country-level demand functions for some types of tomato.



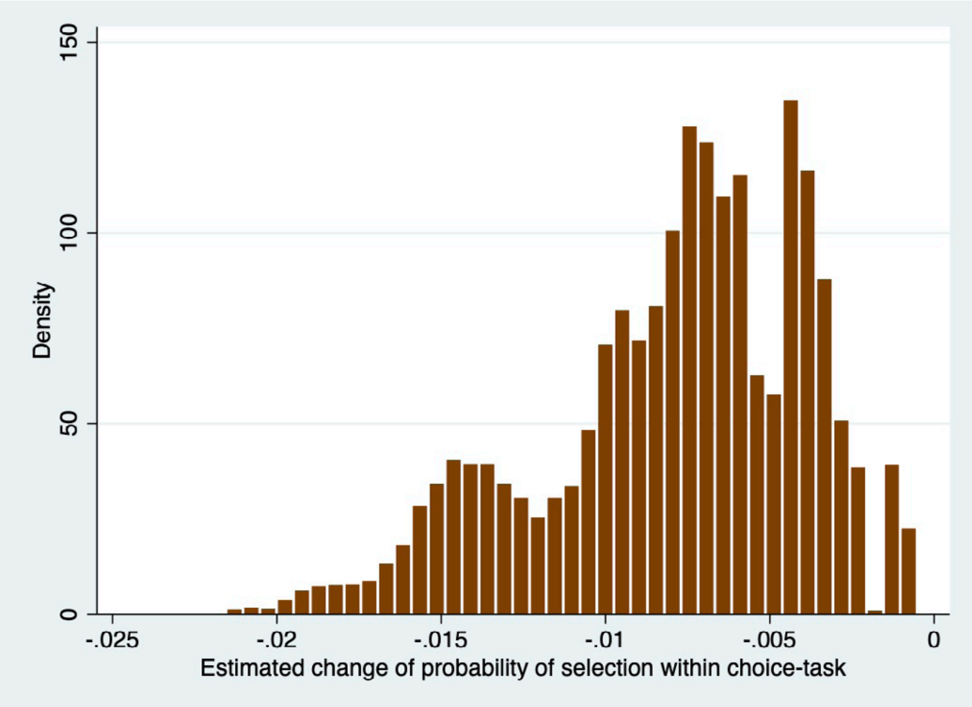
ty at a price increased by ten percent? This comes down to computing the choice probabilities for all five alternatives in each choice task, i.e. the probability vectors with the

Figure 4. Iso-Quantile Plots of Bivariate Kernel Density distributions for MWTP estimates for salad and date-shaped tomatoes in the four countries.



price increase for certitication ($\mathbf{p}^1$) and without such change ($\mathbf{p}^0$) for the baseline tomato. Then the difference between the two sets of predicted selection probabilities ($\mathbf{p}^1$ - $\mathbf{p}^0$) for the alternatives with the profile of interest is computed and the distribution of these values examined. In our case we have 13,071 choice sets containing the baseline profile in the German sample. An increase of ten percent would always result in a decreased selection probability, as shown in Figure 5. This suggests that either the price change should be lowered, or some additional positive features should be added, for example organic certification, that the German consumers seem to strongly appreciate. One can also envisage iterating this exercise at gradually lower price increases until a sufficient fraction of the within sample predicted choices show a positive value.

Figure 5. In-sample simulation of selection probabilities for workers' health and safety certification at 10% price increase.



5. Conclusions

We conduct identical surveys across four countries to estimate the marginal WTPs for a set of attributes of fresh tomatoes. Estimates were obtained in WTP-space, which several authors encourage practitioners to adopt to obtain more reliable, interpretable and plausible MWTP distributions. Specific differences in preferences across countries have been highlighted in terms of sign and magnitude of the coefficient estimates, conditional MWTPs, correlation coefficients and market shares. Further, simulations of choice purchase behaviour were inferred within-sample and at the population level. These were discussed with regards to their effects of price changes on tomato profiles in the four markets, to explore marketing implications of population distributions of marginal MWTPs and to exemplify the range of uses analysts can make of these model post-estimations.

The method can produce evidence that could be used to support the design of strategies aimed at consolidating the position of Italian tomatoes on traditional European markets, such as Germany and the UK; and at the same time, it could help Italian producers to identify what types of tomato produce to improve their share in Norwegian and Russian markets.

The tomato profile, which shows the highest probability to be purchased in all markets is vine, red and sold loose (unpackaged). However, some specific tomato profiles have been identified for each market. In Germany, where Italian tomatoes are preferred to those coming from other countries, consumers ask tomatoes whose quality is certified for workers' health and safety and eco-sustainability, but only within a restricted price range, as shown by the in-sample inference, where a ten percent increase was found too high. Salad-shaped tomatoes is more likely to be purchased when packaged in trays, while the use of this package should be avoided for vine-shaped tomatoes. In the UK, the same types of tomato certifications are also appreciated. However, the UK consumers seem to be not interested in the country of origin, unlike German consumers. Norwegian and Russian consumers adopt an intermediate behaviour. Consequently, tomatoes from Italy may not enjoy the same level of competitive advantage abroad, as it is generally assumed, and hence export penetration strategies should vary across countries. To sell more tomatoes in Norway, Italian producers should offer juicy-pulp tomatoes and certify their quality with organic and worker's health and safety labels. Cherry tomatoes are more appreciated in the UK market if are packaged in a net. Finally, Russians prefer thin-skin tomatoes and appreciate certifications for workers' health and safety and eco-sustainability, rather than for organic production.

Further research should address some of the limitations of our study in order to confirm or disconfirm our findings, which were only illustrative in their nature. In fact, we are aware about a number of limitations of our study. They arise from the choices we have been forced to make regarding the experimental design and the data analysis. Firstly, to assure that the survey respect international quality standards for market research in a cross-country context, we decided to collect data engaging a market research company. The use of such online survey has grown rapidly in social science and policy research in the last ten years (Lehdonvirta et al., 2020). However, it is well known that data generated in this manner could be affected by self-selection issues and non-random and non-representativeness of the samples, and these limitations should be taken into account in evaluating the external validity of our results. Further, to reduce the choice task complexity, we simulated a forced choice decision context, asking consumers to imagine they had to decide to buy one of the proposed options, without including an opt-out alternative. This decision has been supported by Dhar and Simonson (2003) who suggested that forced choice may generate more accurate and complete results in categories of familiar commodities in which the deferral option is available but rarely exercised. We assumed that this is the case of our research given that participants in our survey are consumers of fresh tomatoes, fresh tomatoes are characterized by high versatility in cooking and individual diets, and the expenditure of this product has a low impact on the individual/household budget. However, we are aware that this can be seen as a limitation of our study. Therefore, market shares estimates could be affected by the adopted choice design. This possibility must be taken into account by the reader. Moreover, each choice card includes several attributes and levels and, despite this well simulates the real-life scenario faced by consumers when purchasing fresh tomatoes, at the same time, respondents may not have attend to a certain number of attributes. An attribute-not-attendance phenomenon (Hensher, 2010) could consequently affect this survey as a limitation. We plan to analyse this eventuality through a further paper, given that it is not the focus in this one. Another limitation is related to the econometric approach. We chose to use Halton draws for simulations, despite the use of Scrambled Sobol draws could be more appropriate, as demonstrated by Czajkowski and Budziński (2019). Our choice stemmed from the fact that one of the aims of this paper is to provide the reader with estimation and post-estimation codes used in data analysis to facilitate dissemination. Further, it is worth observing that we took the exporter viewpoint, and consequently we did not adjust prices according to the national purchasing power given that results are mainly presented at a country level. Therefore, it is important to underscore that, in the case of a country comparison, the same tomato profile could be perceived as relatively cheap or expensive in countries with different purchase powers. These cases could affect choice probability estimates. Finally, we used maximum likelihood estimators, which suffer from the limitation of local optima, and assumed normal and log normal distributions of qualitative attributes and price, respectively, for the random parameters. Assumptions of unimodal symmetric distributions surely affect our estimates and the analysis might also have been conducted with more flexible semi-parametric mixtures (Train 2016, Caputo et al. 2018, Scarpa et al. 2020).

Despite these limitations, this study presented useful insights into consumer choices and their impact on market competitiveness for food producers. It demonstrated how the use of stated food choice experiments in a multi-country context is focal to support decision makers in determining which types of product to grow and promote, how to manage the marketing mix, what communication content to emphasize in advertising campaigns and how adopt price differentiation strategies in different markets to face consumers' demand.

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