Food Quality and Preference 80 (2020) 103825

Contents lists available at ScienceDirect

Food Quality and Preference

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

Personality traits, knowledge, and consumer acceptance of genetically modified plant and animal products

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ARTICLE INFO

Keywords:
Big Five
Consumer preference
Knowledge
Novel food
Genetic modification
Salmon

ABSTRACT

Several studies have investigated the associations between personality traits and consumer behavior, but little attention has been paid to the role of personality traits in the acceptance of genetically modified (GM) food products or knowledge concerning the application of GM technologies. We used a large Norwegian survey to investigate the associations between personality traits, knowledge about GM use in agriculture, attitudes, and willingness to pay (WTP) to avoid GM foods. Using a random effect interval regression model, we found premiums between 19% and 23% to avoid GM soybean oil, GM-fed salmon, and GM salmon. Neuroticism was associated with increased acceptance of GM soybean oil. Conscientiousness was associated with increased acceptance of GM-fed and GM salmon, and agreeableness was associated with increased aversion against these products. Conscientiousness and agreeableness were also associated with knowledge. Agreeable respondents were less likely to think that genetic modification was applied in Norwegian agriculture, and conscientious respondents were more likely to wrongly think so. Attitudes towards naturalness of foods were strongly correlated with increased WTP to avoid GM foods. Current policy restrictions concerning the use of GM technologies are likely to affect the perceived safety of GM foods. Information and more liberal regulations may change attitudes towards GM foods and reduce the resistance against GM technologies over time.

1. Introduction

The potential risks and benefits of genetically modified (GM) foods have created concerns among consumers since the first GM food product was approved for human consumption in 1994. We focus on Norwegian consumer preferences as measured by willingness to pay (WTP) to avoid GM foods. The results in Bazzani, Gustavsen, Nayga, and Rickertsen (2018) indicate that Norwegian consumers are less willing to consume GM foods than U.S. consumers. However, Rickertsen, Gustavsen, and Nayga (2017) found that the average WTP to avoid GM soybean oil, GM-fed salmon, and GM salmon were similar and around 10% in both Norway and the U.S. This is substantially less than the premiums reported for these products about twenty years ago (Chern, Rickertsen, Tsuboi, & Fu, 2002).

Köster (2009) emphasized on taking psychological factors into account to understand the unconscious food related decision-making process. However, little attention has been paid to the effect of personality in the literature on WTP for GM foods. Personality may be defined as: 'relatively enduring patterns of thoughts, feelings, and behavior that reflect the tendency to respond in certain ways under certain circumstances' (Roberts, 2009: 140). We will investigate the role of personality using the Big Five personality traits (Goldberg, 1981). The five traits are openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (OCEAN), and these traits have successfully predicted behaviors across tasks and situations.[1] Personality traits are not absolutely fixed over the life cycle, but they change at different rates in different stages (Almlund, Duckworth, Heckman, & Kautz, 2011), and Cobb-Clark and Schurer, 2012 showed that personality traits are relatively stable among adults.

Knowledge is an important factor in consumer decision-making and information processing activities (Mitchell, 1982). Theories of preference formation and decision making indicate that when exposed to a product or receiving information from the environment, consumers create an overview of the situation before they form preferences

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[1] The Big Five personality traits are also known as the five-factor model or the OCEAN model. The traits have been able to explain and predict a variety of life outcomes including health status, educational achievements, and earnings (Mueller & Plug, 2006; Hampson, Goldberg, Vogt, & Dubanoski, 2007), risk and time preferences (Rustichini, DeYoung, Anderson, & Burks, 2012), and financial and investment decisions (Brown & Taylor, 2014). Almlund et al. (2011) provide a comprehensive review.

https://doi.org/10.1016/j.foodqual.2019.103825
Received 20 May 2019; Received in revised form 3 October 2019; Accepted 9 October 2019
Available online 16 October 2019

(Jaeger, Wakeling, & MacFie, 2000). Knowledge about regulations on GM food products can affect consumers' attitudes, because adopted policies are viewed as decisions made by experts (Lusk, 2011). In Norway, no GM products are produced, sold, or used as feed (Mattilsynet, 2012). Using a field experiment, Paksersht, McFadden, and Lagerkvist (2017) exposed individuals to different policy contexts and showed that restrictive policy scenarios induced the highest opposition against GM potato in Sweden.

This study has three objectives. The main objective is to investigate the effects of the OCEAN traits and knowledge about public policy on consumer preferences for GM foods. We estimate the WTP to avoid GM soybean oil (a plant-based GM food), GM-fed salmon (an animal that has been eating GM feed), and GM salmon (a GM animal). Second, we investigate the role of the OCEAN traits in having knowledge about current policy on the use of genetic engineering in agriculture. Finally, our products are identical to the products used in Rickertsen et al. (2017). However, we use a different and larger data set, and it is of interest to check the robustness of the results in their study.

2. Literature review

Personality has been associated with self-rated health and health outcomes, food choices, and taste preferences (e.g., Byrnes & Hayes, 2013; Chen, 2007; Gale, Batty, & Deary, 2008; Yangui, Costa-Font, & Gil, 2016). Several studies have investigated the effects of the OCEAN traits on food preferences. Goldberg and Strycker (2002) found that items constituting openness, conscientiousness, and agreeableness were associated with high consumption of fiber and avoidance of fat in food; Saliba, Wragg, and Richardson (2009) found that openness to experience was associated with a dislike of sweet taste in white wine; Knaapila et al. (2011) found that openness and extraversion were associated with seeking novel aspects in food and less food neophobia; Chang, Tseng, and Chu (2013) found that open, conscientious, and extrovert individuals cared more about food values, and had positive perception of food traceability labels; Keller and Siegrist (2015) found that openness and conscientiousness were associated with consumption of fruits and vegetables and restrained eating behavior, while neuroticism was associated with overeating and consumption of sweet and savory food; Grebitus and Dumortier (2016) found that agreeableness was associated with preference for organic tomatoes; Bazzani, Caputo, Nayga, and Canavari (2017) found that extraversion and agreeableness explained preference heterogeneity for local applesauce; Mora, Urdaneta, and Chaya (2019) found that extraversion, agreeableness, and conscientiousness were associated with positive emotional responses, and neuroticism was associated with negative emotional responses in wine tasting; and Gustavsen and Rickertsen (2019) found that high scores on extraversion and openness to experiences increased the frequency of wine consumption and high score on agreeableness reduced the frequency.

As far as we know, the only study that has investigated the effects of the OCEAN traits on WTP for GM foods is Lin, Ortega, Caputo, and Lusk (2019), who used a hypothetical choice experiment to investigate the effect of personality traits on the WTP for GM pork in the U.S., China, and Italy. They found that openness increased the valuation of GM pork and conscientiousness decreased the valuation in the U.S. and Italy. Agreeableness decreased and extraversion increased the valuation of GM pork among U.S. participants. Two studies have investigated the effects of the OCEAN traits on consumer preferences for labelling of GM foods. Peschel, Grebitus, Alemu, and Hughner (2019) used a hypothetical choice experiment and focused on GM-free, pesticide-free, and region of origin labelling of dates. Their results suggest that U.S. participants with high scores on openness, neuroticism, extraversion, and low scores on conscientiousness lost utility from dates labelled as GM-free only. DeLong and Grebitus (2018) used survey data and found that agreeable, conscientious, and extrovert participants wanted labelling of GM sugar and soft drinks with GM sugar contents, while open and neurotic individuals disagreed with GM labelling of these products.

OCEAN traits have also been associated with level of general knowledge, knowledge sharing, and knowledge seeking behaviors (Furnham & Chamorro-Premuzic, 2006; Matzler, Renzl, Müller, Herting, & Mooradian, 2008). Agreeableness and conscientiousness were associated with knowledge sharing, and conscientiousness was associated with knowledge acquisition (Gupta, 2008). Neuroticism and extraversion were negatively, and openness was positively correlated with general knowledge (Chamorro-Premuzic, Furnham, & Ackerman, 2006; Rolfhus & Ackerman, 1999). However, McEachern and Warnaby (2008) showed that openness to experience was negatively associated with knowledge about value-based labeled meats.

In the literature concerning GM foods, type of knowledge such as objective vs. subjective knowledge (e.g., House et al., 2004); knowledge about genetics (e.g., McFadden & Lusk, 2016); and product specific information such as risks and benefits of GM products (e.g., Lusk et al., 2004) have been studied. Several findings indicate that consumers' knowledge about GM foods is typically quite limited, and that GM-food aversion is mainly driven by subjective rather than objective knowledge (House et al., 2004; Huffman, Rousu, Shogren, & Tegene, 2007; Lusk et al., 2004). Wuepper, Wree, and Ardali (2018) asked four relatively basic questions to test German consumers' knowledge about GM foods. None of the 397 respondents answered all the questions correctly, and 36% did not answer any of them correctly. Results of a U.S. study with a broader set of questions suggest that peoples' beliefs have no solid scientific groundings, and 30–50% of the respondents had little or no knowledge about genetics (McFadden & Lusk, 2016).

In a *meta*-analysis of 57 WTP studies of GM foods conducted in several countries, Lusk, Jamal, Kurlander, Roucan, and Taulman (2005) found an average premium of 23% for conventional products. Compared with consumers in the U.S., European consumers indicated a 29% higher WTP for the conventional alternatives. In another *meta*-analysis, Frewer et al. (2013) found that public perceptions of benefits associated with GM food consumption had increased over time, but so had the perceptions about its risks resulting in consistent gaps in GM aversion between Europe and the U.S. They also found that GM technologies were more acceptable when applied to plants rather than animals. Recent results from several countries also indicate substantial positive WTP premiums to avoid GM foods. In a sample of U.S. students, 75% of the participants were on average willing to pay a 13% premium for non-GM items in restaurants (Lu & Gursoy, 2017). In a study including Belgium, France, the Netherlands, Spain, and the United Kingdom, participants were willing to pay 4 to 13 times more to avoid GM rice, with French consumers having the largest avoidance and Belgian consumers the lowest (Delwaide et al., 2015). In a sample of Russian consumers, only 20% of the participants were willing to purchase GM bread at a 50% discount as compared with conventional bread (Delmond, McCluskey, Yormirzoev, & Rogova, 2018).

3. Materials and methods

3.1. The survey

We used data from the Norwegian Monitory Survey (NMS). NMS is a nationally representative survey that has been conducted every second year since 1986 with 3,000–4,000 respondents in each round. It covers topics such as demographics, political and social preferences, ethical viewpoints, respondents' general values, food preferences, eating habits, health-related behaviors, and life-style choices (Ipsos-MMI, 2016). All the questions needed to construct the OCEAN traits were not included in NMS before 2015, and data for this year was used. The number of respondents was 3,981, and the respondents were assured that any given information was anonymous and that they could quit the survey whenever they wanted to.

Cobb-Clark and Schurer (2012) showed that although personality traits are not completely fixed, they are relatively stable among adults

Table 1
The Big Five personality traits.

Trait	APA definition [a]	Items [b]
Openness to experience	The tendency to be open to new aesthetic, cultural, or intellectual experiences	• Original with new ideas • Lively imagination • Likes to speculate and play with ideas • Few artistic interests
Conscientiousness	The tendency to be organized, responsible, and hardworking	• Do a thorough job • Careless • Usually have a messy life • Make plans and follow them up
Extraversion	An orientation of one's interests and energies toward the outer world of people and things rather than the inner world of subjective experience	• Talkative • Tends to be quiet • Shy • Outgoing and social
Agreeableness	The tendency to act in a cooperative, unselfish manner	• Helpful and selfless towards others • Can be cold and distance • Considerate and friendly to most of people • May sometimes be rude
Neuroticism	A chronic level of emotional instability and proneness to psychological distress	• Depressed • Relaxed, cope well with stress • Worries too much • Gets nervous easily

Source: Table 1 is adopted from Almlund et al. (2011).
Notes: [a] Definitions according to American Psychology Association's (APA) dictionary of psychology (APA, 2007). [b] Items are adjusted based on BFI-20 developed by Engvik and Clausen (2011).

aged 25 – 64 years, and we excluded respondents younger than 25 and older than 64 years old from the analysis. This excluded 1,721 respondents. Furthermore, we excluded 74 respondents due to missing values for the income variable, which left 2,186 respondents.

3.2. Measurement of variables

Consumers acceptance of GM foods was measured by the price premiums they were willing to pay to purchase the non-GM versions of each product. Respondents were asked to answer the following three questions: (i) "Imagine that you are purchasing soybean oil. The store has two types of oil. The first is made from non-genetically modified soy, and the other is made from genetically modified soy. How much more are you willing to pay for the non-genetically modified oil as compared with the genetically modified oil?". (ii) "Imagine that you are purchasing salmon. The store has two types of salmon. Non-genetically modified soy has been a part of the feed of the first type of salmon and genetically modified soy has been a part of the feed of the other type. How much more are you willing to pay for the salmon that has been fed non-genetically modified soy?". (iii) "Imagine a genetically modified salmon has been developed. The store has conventional farmed salmon and the genetically modified salmon. How much more are you willing to pay for conventional salmon?". The answer alternatives for each question were "nothing, will not pay more", "a maximum of 20% more", "21–50% more", "more than 50% more", and "do not know". We excluded 34 respondents with missing values for one or more of these alternatives, which left 2,152 respondents.

Knowledge was measured by the answers to the question: "Do you think genetic modification is used often, occasionally, rarely, or never in agriculture in Norway?". Respondents also had the 'do not know' alternative.

Personality traits were measured by a 20-item version of Big-Five Inventory (BFI-20), which was developed by Engvik and Clausen (2011). They constructed each trait on the basis of several items. Table 1 shows the five traits, their definitions according to American Psychology Association (APA) dictionary of psychology (American Psychological Association (APA), 2007), and the items associated with each trait. Each item was measured by self-reported scores on a scale from 1 (the item does not describe the respondent at all) to 7 (the item describes the respondent very well). BFI-20 was developed for situations where the time is limited, and it reached adequate levels of structural validity, factor divergence, maximal representation, test–retest reliability, and criterion validity (Engvik & Clausen, 2011).

We control for socioeconomic characteristics, general values associated with the environment and food's naturalness, and trust in food authorities. Such values and trust have been shown to be important for GM foods (e.g., Bredahl, 2001; Rickertsen et al., 2017; Traill et al., 2004). Value associated with environment was measured by the statement: "I am concerned with what I can personally do to protect the environment and natural resources", with answer alternatives given by a scale from 1 (totally agree) to 4 (totally disagree). We created a dummy variable, which was set to 1 if the individual totally or somewhat agreed with this statement, i.e., responded 1 or 2. Value associated with the naturalness of food was measured by the question: "When you are shopping food for your household or yourself, on which of the factors listed below do you put a great emphasize on?" Natural ingredients was one of the 25 factors listed, and multiple choices were allowed. We created a dummy variable set to 1 if natural ingredients was among one of the chosen items and zero otherwise. Trust in food authorities was measured by the answers to the question: "Here you can see logos of the three information offices for agricultural products. Which of the information offices do you think provides trustworthy and credible information?" Multiple choices were allowed, and we created a dummy variable set to 1 if at least one of the information offices was chosen and zero otherwise.

3.3. Construction of personality traits

The five personality traits were constructed in a two-step procedure. In the first step, we used confirmatory factor analysis (CFA) as implemented by the -sem- command in Stata/MP 15 (StataCorp, 2015). Following Jöreskog, Olsson, and Wallentin (2016: 283), we specified the general model:

$$x = \tau_x + \Lambda_x \xi + \delta \quad (1)$$

where $x = (x_1, \cdots, x_j)'$ is a vector of the observed items, $\tau_x = (\tau_{x1}, \cdots, \tau_{xj})'$ is a vector of constant terms, $\xi = (\xi_1, \cdots, \xi_p)'$ is a vector of the latent personality traits, and $\delta = (\delta_1, \cdots, \delta_j)'$ is a vector of error terms. The factor loadings in matrix Λ_x was constrained to be zero for items not associated with the specific personality trait. We assumed that

$\xi \sim N(0, \Phi)$ and $\delta \sim N(0, \Theta_\delta)$ are independently distributed, and the error covariance matrix Θ_δ is diagonal. The covariance matrix will be $\Sigma = \Lambda_x \Phi \Lambda_x^{'} + \Theta_\delta$ and it follows that $x \sim N(\tau_x, \Sigma)$. As is common, we let τ_x be unconstrained, and collected Λ_x, Φ, and Θ_δ into the parameter vector θ (Jöreskog et al., 2016: 286).

Maximum likelihood estimates of θ were found by minimizing the fit function with respect to θ:

$$F_{ML}(\theta) = \log\|\Sigma\| + \mathrm{tr}(S\Sigma^{-1}) - \log\|S\| - J \tag{2}$$

where S is the sample covariance matrix, and J is the number of observed items. We used the Satorra and Bentler (1994) -vce(sbentler)- option in Stata/MP 15. This option provides robust standard errors and valid test statistics in the presence of non-normalities (StataCorp, 2015). The latent personality traits in the first step were predicted from the estimated model.

As discussed earlier, personality traits have been found to be relatively stable in the age range of our sample, but they may not be fixed over the life course. We followed a standard approach in the literature (e.g., Bucciol & Zarri, 2017), and implemented a second step to adjust for possible changes in the traits over the life course. In this step, we conditioned each of the predicted traits from the first step on a second-degree polynomial of age: $\widehat{\xi_p} = \alpha_{p1}(age) + \alpha_{p2}(age)^2 + \varepsilon_p$, standardized the resulting residuals, and used them as measures of personality traits in the subsequent analysis.[2]

3.4. Econometric models

We followed the specification in Rickertsen et al. (2017), and estimated WTP premiums and the associated marginal effects of the explanatory variables. WTP premiums were available in the intervals described above, and an interval regression model was used. The interval regression model is a generalization of the Tobit model with known intervals (Amemiya, 1973).

For each respondent, we have three WTP premiums, one for each product, and this panel structure was taken into account. We applied a random effects interval regression model, in which individual characteristics that are constant across products were treated as random parameters. Each respondent's WTP premium was specified as:

$$WTP_{ig} = G_1 Z'_i \beta_1 + G_2 Z'_i \beta_2 + G_3 Z'_i \beta_3 + v_i + e_{ig} \tag{3}$$

where the subscript $i = 1, \ldots, n$, denotes respondents and the subscript $g = 1, 2, 3$ denotes products. G_1, G_2,and G_3 are dummy variables, and each dummy variable took the value of one for the relevant product (GM soybean oil, GM-fed salmon, or GM salmon). Z'_i is the vector of the explanatory variables containing the age-adjusted predicted personality traits, knowledge, and control variables, and β_1, β_2, β_3 are parameter vectors associated with the explanatory variables for GM product g. The error term v_i represents respondent-specific random variation that was assumed to be iid $N \sim (0, \sigma_v^2)$.This variation was assumed to be constant across the products for one respondent. The error term e_{ig} is an observation-specific error term that represents all other unobserved factors affecting the WTP, and it was assumed to be independent of v_i and $N \sim (0, \sigma_e^2)$. The proportion of the total variance contributed by the panel-level variance component is $\rho = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_e^2}$, where $\sigma_v^2 = \mathrm{Var}(v_i)$ and $\sigma_e^2 = \mathrm{Var}(e_{ig})$. When this proportion is high, the respondent-specific variation is high, the panel structure is important, and the pooled estimator will give incorrect standard errors (StataCorp, 2015). We used the -xtintreg- procedure in Stata/MP 15 to estimate this model (StataCorp, 2015).

We estimated a probit model to investigate the effects of personality traits on the probability of having incorrect knowledge concerning the use of genetic modification, i.e., thinking that genetic modification is applied often, occasionally, or rarely in Norwegian agriculture. The observed binary outcome variable was defined as:

$$y_i = \begin{cases} 1, & \text{if} \quad y^* = Z^{'}\gamma > 0 \\ 0, & \text{otherwise} \end{cases} \tag{4}$$

where y^* is the continuous latent lack of knowledge variable, Z' is the vector of all explanatory variables used in Eq. (3) except for knowledge, and γ is the vector of parameters. The probability of lack of knowledge given the explanatory variables is $p(y = 1|Z) = \Phi(Z'\gamma)$ where Φ () is the standard normal cumulative distribution function.

4. Results

4.1. Descriptive analysis

The distributions of the WTP premiums to avoid GM alternatives for 2,152 respondents are shown in Table 2. Between 20 and 25% of the respondents indicated that they would pay nothing to avoid the GM alternatives, around 32% indicated that they would pay up to 20% more, 14–18% were willing to pay 20–50% more, and 11–15% indicated that they were willing to pay more than 50% more. Around 15–20% of the respondents chose the 'do not know' option. These respondents were not always the same for all the alternatives, and we excluded 557 respondents who answered 'do not know' for at least one alternative, which left 1,595 respondents.

Table 3 provides the percentage distribution of the answers to the knowledge question. Only 30% answered correctly, i.e., never. Approximately 56% answered wrong, 10% did not know, and the rest did not answer the question. We aggregated the responses and created a dummy variable set to 1 if the respondent answered this question incorrectly; often, occasionally, or rarely and zero otherwise (including do not know and missing value).

The mean values and standard deviations of the 20 items used to construct the OCEAN traits are shown in Table 4 (columns 2 and 3). Estimation results of the CFA and some measures related to the validity of the constructed traits are shown in the five last columns of Table 4. The scores on some of the items are reversed, for example, a respondent who scored high on the item (non) unaesthetic is very aesthetic. It was recorded a missing value for 108 respondents on one or more of the 20 items. The summary statistics reported in Table 4 are based on 1,487 respondents with no missing value for any of the 20 items. However, personality traits can be constructed also for these respondents as long as there is at least one non-missing value among the items for each trait, and the number respondents in the subsequent analysis is 1,595.

In column 2, the mean scores for items associated with agreeableness were highest (5.1 to 6.0), and they were lowest for items associated with neuroticism (2.4 to 3.6). Columns 4 and 5 show the standardized factor loadings and their Satorra-Bentler robust standard errors, respectively. According to Hair, Black, Babin, Anderson, and Tatham (2014: 618), these factor loadings should be above |0.5|, which is the case with the exception of five items. Columns 6–8 show the average variance extracted (AVE), Cronbach's alpha values (Alpha), and the construct reliability (CR) for each of the five traits. According to the critical values of these measures provided in Hair et al. (2014: 619), eight out of 15 measures indicate a high degree of accuracy of the constructed traits, and most of the inaccuracies are related to the AVE values. To be consistent with BFI-20, we retained all the items in the constructed traits.

Fig. 1 shows the distribution of the predicted personality traits from the first step (unadjusted for age), with their means and standard deviations. The mean values were always close to zero. However, the distribution of openness to experience, extraversion, and neuroticism were much wider than the distributions for conscientiousness and agreeableness.

[2] The results of our model, did not change substantially when the traits, as constructed in the first step, were used in the analysis. Further results are available upon request.

Table 2
Willingness to pay to avoid GM alternatives, percentage distributions.

Premium	GM soybean oil	GM-fed salmon	GM salmon
Nothing	21.0	24.6	20.0
Max. of 20% more	31.5	32.0	31.1
21–50% more	13.7	14.1	18.0
More than 50% more	14.0	11.1	15.4
Do not know	19.8	18.3	15.5

Note: Based on 2,152 respondents aged 25 to 64 years.

Table 3
Knowledge concerning the use of GM technologies in Norwegian agriculture, percentage distribution.

Frequency	Percent
Often	6.0
Occasionally	22.8
Rarely	27.2
Never	29.9
Do not know	9.9
Missing value	4.5

Note: Based on 1,595 respondents aged 25 to 64 years.

Table 5 provides the summary statistics of the explanatory variables for all the respondents (total; $n = 1{,}595$), for respondents who had a WTP = 0 for at least one of the GM-free alternatives (accepters; $n = 501$), and for respondents who had a WTP greater than 0 for all the GM-free alternatives (avoiders; $n = 1{,}094$). The last column of the table reports results of a *t*-test for equality of the mean values between avoiders and accepters. Accepters of GM products were on average less conscientious, less extrovert, and less agreeable than avoiders. In the total sample, the average age was 46 years, 48% were male, 70% had completed a bachelor's degree, 41% had children aged 15 years or less in the household, and 51% had grandparents who own or had owned a farm. About 75% of the total sample considered at least one of the information offices for agricultural products (dairy, fruits and vegetables, or meat) to be a trustworthy source of information, 58% were concerned with protecting the environment, and 62% claimed to put great emphasize on natural ingredients while shopping food.

The correlation matrix between the age-adjusted personality traits are presented in Table 6. The correlations printed in bold are significantly different from zero at the 5% level of significance. Even though several of the correlations were significantly different from zero, none were above 0.64.

4.2. Willingness to pay

Table 7 provides the parameter estimates and standard errors of the WTP and probit models with and without personality traits. Likelihood-ratio tests rejected no effects of personality traits in both models (p-values < 0.02), and we discuss the results of the models with personality traits.[3] In the WTP model, the contribution of the panel level variance to overall variance was high (0.91). The estimated marginal effects of the socioeconomic and attitudinal variables were similar in the models with and without personality traits, which correspond well with the results in Grebitus and Dumortier (2016), who found that adding personality traits did not substantially alter the effect of values on demand for organic products.

The estimated parameters of the WTP model represent the marginal WTP premiums to avoid the GM alternatives. The alternative specific constants represent the WTP to avoid the associated GM alternatives for a non-existent reference respondent, i.e., a female with zero age, zero income, etc. Most of the socioeconomic variables were insignificant. For GM salmon, a one-year increase in age decreased the WTP by 0.08%, and 1% increase in income increased the WTP by 1%.

Naturalness and trust were important for the WTP premiums. The effects were particularly large for naturalness. Respondents who found naturalness important, were willing to pay more than 15% more for the conventional alternatives. Trust in the information offices in agriculture reduced the WTP premium to avoid GM soybean oil and GM salmon by about 1.7%. Knowledge also had significant but moderate effects on the WTP, the premiums were 2–3% lower among respondents who thought that genetic modification is already being applied in Norwegian agriculture than among other respondents.

Conscientiousness, agreeableness, and neuroticism were associated with WTP to avoid the GM alternatives. WTP to avoid GM-fed and GM salmon decreased by around 1.2% as conscientiousness increased by one standard deviation, and increased by almost 0.9% as agreeableness increased by one standard deviation. WTP to avoid GM soybean oil decreased by 0.7% as neuroticism increased by one standard deviation. Fig. 2 illustrates the significant relationships. The horizontal axes represent the scores of the personality traits, and the vertical axes show the average predicted WTP premiums that respondents were willing to pay to avoid the corresponding GM alternative. The two top panels show the effects of conscientiousness, the two middle panels show the effects of agreeableness, and the bottom panel shows the effect of neuroticism. The dotted lines give 95% confidence intervals for the point estimates. Fig. 2 indicates that increased scores of conscientiousness and neuroticism decreased GM aversion, whereas increased scores of agreeableness increased the aversion.

We bootstrapped the sample using 300 repetitions, predicted the WTP for each sample, and calculated the average premiums to avoid each GM alternative. The estimated percentage premiums and the associated standard errors are presented in Table 8. The premiums to avoid GM soybean oil was 21%, to avoid GM-fed salmon was about 19%, and to avoid GM salmon was almost 23%. The total effects of personality traits on WTP premiums are relatively small.

4.3. Knowledge of the use of GM technologies

A positive sign of an estimated parameter of the probit models in Table 7 indicates an increased probability of not knowing the current restriction on the use of GM technologies in Norwegian agriculture. Rather than discussing the parameter estimates, we describe the average marginal effects (AMEs), i.e., the average change in probability when the associated variable increases by one unit.

In the model with personality traits, the pseudo R-squared value was low (0.03), however, there were some statistically significant AMEs. A one-year increase in age decreased the probability of incorrectly thinking that GM technologies are in use by 0.5%, and having grandparents who own or have owned a farm reduced this probability by 9%. Rather surprisingly education does not have an effect. The AMEs indicate that a one standard deviation increase in conscientiousness increased the probability of having incorrect knowledge by 4%, and a one standard deviation increase in agreeableness decreased the probability of the incorrect knowledge by 6%. Fig. 3 illustrates these significant relationships. The horizontal axes show scores of conscientiousness and agreeableness, and vertical axis show the average predicted probability

[3] We did several other specification tests. First, we tested a WTP model with identical marginal effects and alternative-specific constants (ASC) for the three GM foods. This model was rejected (p-value = 0.00). We also tested WTP models with only socioeconomic variables or personality traits, and these models were rejected (p-values = 0.00). Second, we tested the probit model against a model excluding attitudes, and this model was not rejected (p-value = 0.43). We also tested a probit model with only personality traits, and this model was rejected (p-value = 0.00). To be consistent with the specification of the WTP model, we report the results of the full probit model. More estimation results can be provided upon request.

Table 4
Summary statistics of the items used to construct the OCEAN traits.[a]

Item	Mean	Std. dev.	Std. factor loadings [b]	SB std. err. [c]	AVE [d] (%)	Alpha [e]	CR [f]
Openness to experience					39	0.66 (0.63)	0.70
Original	4.16	1.48	0.73	0.02			
Imaginative	4.33	1.68	0.65	0.02			
Ideas	4.38	1.59	0.70	0.02			
(non) Unaesthetic [g]	4.41	2.00	0.32	0.03			
Conscientiousness					27	0.54 (0.57)	0.59
Thorough	5.82	1.06	0.45	0.03			
(non) Careless [g]	4.70	1.59	0.38	0.03			
(non) Messy [g]	5.59	1.50	0.65	0.03			
Discipline	5.00	1.35	0.55	0.03			
Extraversion					53	0.80 (0.78)	0.82
Talkative	4.49	1.62	0.71	0.02			
(non) Quiet [g]	4.46	1.73	0.76	0.02			
(non) Shy [g]	5.23	1.62	0.64	0.02			
Social	4.93	1.52	0.80	0.02			
Agreeableness					27	0.58 (0.63)	0.60
Helpful	5.33	1.23	0.44	0.03			
(non) Cold [g]	5.36	1.51	0.65	0.03			
Friendly	6.03	1.02	0.50	0.03			
(non) Rude [g]	5.10	1.60	0.48	0.03			
Neuroticism					45	0.74 (0.73)	0.77
Depressed	2.38	1.49	0.67	0.02			
(non) Relaxed [g]	3.27	1.57	0.56	0.02			
Worried	3.64	1.80	0.75	0.02			
Nervous	3.02	1.65	0.70	0.02			
SB-RMSEA[h]			0.08				

Notes: [a] Based on 1,487 respondents aged 25 to 64 years. [b] Standardized factor loadings from performing a confirmatory factor analysis (CFA) using the -sem-command in Stata/MP 15. All the loadings are significant at the 1% level. [c] Satorra-Bentler (SB) robust standard errors, using the -vce(sbentler)- option (Satorra & Bentler, 1994). [d]Average variance extracted (AVE) is variance extracted for the items loading on a construct, calculated as: $AVE = \frac{\Sigma_{i=1}^{k} L_i^2}{n}$, where L_i refers to standardized factor loadings and n to number of loadings on each trait. $AVE > 50\%$ suggests adequate convergence (Hair et al., 2014: 619). [e] Cronbach's alpha values are scale reliability coefficients for the standardized items. Values above 0.6 suggest construct reliability (Hair et al., 2014: 619). Values in parentheses are Cronbach's alpha values from the developers of BFI-20 (Engvik & Clausen, 2011). [f] Construct reliability (CR) is calculated as $CR = \frac{(\Sigma_{i=1}^{k} L_i)^2}{(\Sigma_{i=1}^{k} L_i)^2 + (\Sigma_{i=1}^{k} e_i)^2}$., where e_i refers to error variances. Values above 0.6 suggest reliability (Hair et al., 2014: 619). [g] The score of the item is reversed. [h] Satorra-Bentler (SB) robust root mean squared error of approximation (RMSEA). Values about 0.08 or less suggest a reasonable approximation, and above 0.1 suggest a poor fit (Browne & Cudeck, 1993: 144).

of the incorrect knowledge, and the dotted lines show the 95% confidence intervals for the point estimates. The figure illustrates how increased scores of conscientiousness increased the probability of the incorrect knowledge, while increased scores of agreeableness reduced the same probability.

5. Discussion, implications, and limitations

Our estimated WTP premiums to avoid GM alternatives were between 19 and 23%. These premiums correspond well with the results of the meta-analysis of Lusk et al. (2005), who found an average premium of 23% to avoid GM foods, but they are about twice as high as the premiums reported for the Norwegian respondents in Rickertsen et al. (2017). This difference can be due to differences in the socioeconomic characteristics of the participants in the two samples (e.g., age distribution), survey format (paper versus on-line), and other factors.

In line with the results in McFadden and Lusk (2016) and Wuepper, Wree, and Ardali (2018), we find that respondents were not very knowledgeable about GM-related issues, and around 56% of our sample thought GM technology was applied in Norwegian agriculture.

The lowest aversion was towards a GM-fed animal and the highest against a GM animal. In studies that have compared consumer attitude towards plant based GM foods, GM-fed animals, and GM animals, a corresponding pattern has been observed (Chern et al., 2002; Rickertsen et al., 2017). One explanation could be that consumers become less averse when genetic modification is not directly applied to the final product that he/she consumes. Therefore, GM-fed animal products might be more accepted in the market than GM plant and animal products for human consumption.

Respondents who found natural ingredients to be important indicated much higher premiums to avoid all GM products, which suggests that consumers perceive conventional products more natural than their GM counterparts. This is in line with previous studies, which found perceived lack of naturalness to be an important barrier towards acceptance of GM foods (Rickertsen et al., 2017; Siegrist, 2008). Concerns about unnaturalness of GM foods could change quite rapidly given increased familiarity with these products and information about the similarities between GM techniques and conventional breeding. Similar to the results in Hossain and Onyango (2004) and Siegrist (2000; 2008), our results indicate that trust in food authorities reduced GM aversion. Current strict policy restrictions concerning the use of genetic modification may give the impression that GM foods are less safe. Given a high degree of trust in public authorities, this impression may result in reduced acceptance of GM foods. Finally, as Lusk (2011) and Pakseresht et al. (2017), we find that respondents who did not know that application of genetic modification is prohibited in Norwegian agriculture were less GM averse.

Our results indicate that personality traits are a source of heterogeneity in attitudes towards GM foods, and knowledge about application of genetic modification. Conscientiousness was associated with GM acceptance. This effect is opposite of Lin et al. (2019), who found that conscientious individuals had lower WTP for GM pork in the U.S. and Italy. One possible explanation is that conscientious individuals are thorough and achievement oriented. They may be more likely to base their attitudes on scientific results, which claims no additional risks of consumption of approved GM foods (WHO, 2014). However, when it comes to the knowledge about current use of genetic modification in Norway, our results do not indicate higher knowledge level among conscientious respondents.

Agreeableness was associated with GM aversion. This result

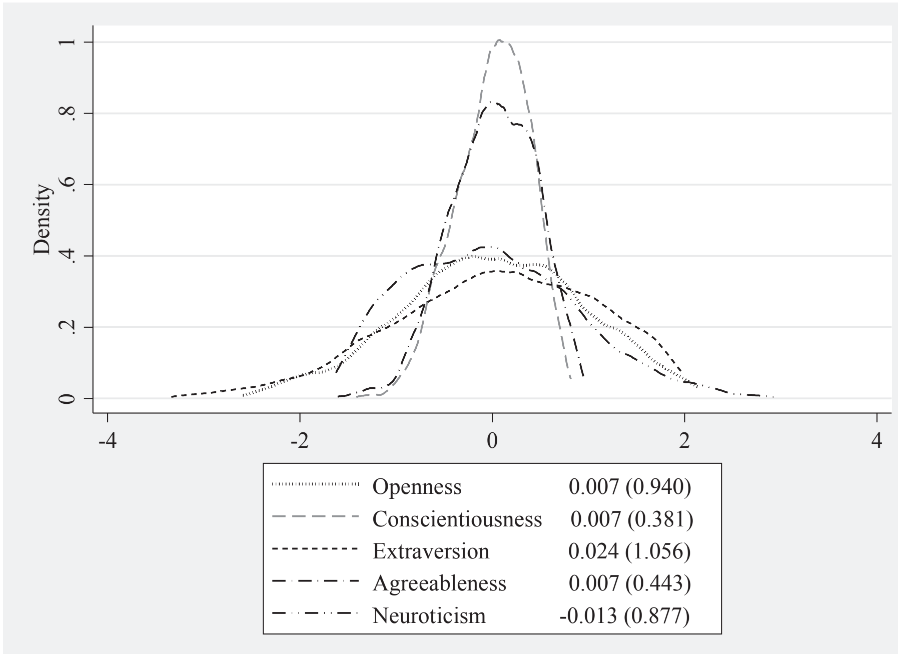

Fig. 1. Distribution of Big Five personality traits – predicted values.
Notes: Based on 1,595 respondents aged 25 to 64 years. Predicted values for latent personality traits from the first step of the CFA (unadjusted for age). Means with standard deviations in parentheses.

Table 5
Summary statistics of the explanatory variables.[a]

Variable	Description	Mean total	Mean accepters [b]	Mean avoiders [c]	T-value [d]
Age	Age in years	46.16 (10.82)	46.18	46.16	−0.03
Income [e]	Log of households' income	6.66 (0.56)	6.56	6.71	**5.06**
Gender	= 1 if male	0.48 (0.50)	0.59	0.42	**−6.33**
Education	= 1 if bachelor or more	0.70 (0.46)	0.63	0.72	**3.69**
Children	= 1 if have children under 15 years old	0.41 (0.49)	0.35	0.43	**2.99**
Farm	= 1 if grandparents have (ever) had a farm	0.51 (0.50)	0.45	0.54	**3.14**
Environment	= 1 if somewhat/ totally concerned with environment	0.58 (0.49)	0.50	0.62	**4.38**
Naturalness	= 1 if natural ingredients matter while shopping	0.62 (0.49)	0.49	0.68	**7.42**
Trust	= 1 if trust in at least one of the food information offices	0.75 (0.44)	0.75	0.75	0.01
Openness[f]	Standardized residuals	0	0.01	−0.00	−0.20
Conscientiousness[f]	Standardized residuals	0	−0.09	0.04	**2.44**
Extraversion[f]	Standardized residuals	0	−0.08	0.04	**2.17**
Agreeableness[f]	Standardized residuals	0	−0.11	0.05	**3.00**
Neuroticism[f]	Standardized residuals	0	−0.00	0.00	0.05
n		1,595	501	1,094	

[a] Standard deviations in parentheses.
[b] Respondents who had a WTP = 0 for at least one of the alternatives.
[c] Respondents who had a WTP greater than 0 for all the three alternatives.
[d] Results of a *t*-test on the equality of the means between avoiders and accepters of GM foods. Bold print indicates significance at the 5% level.
[e] Income in NOK was divided in eleven income groups. We set the respondents' income to the midpoint of the income group. For the highest and lowest income, the censoring point was set as the income.
[f] The traits are standardized net traits.

Table 6
Correlation matrix of personality traits' after correcting for age.

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
Openness	1.00				
Conscientiousness	**−0.17**	1.00			
Extraversion	**0.19**	**0.28**	1.00		
Agreeableness	−0.03	**0.64**	**0.57**	1.00	
Neuroticism	−0.01	**−0.39**	**−0.47**	**−0.43**	1.00

Notes: Based on 1,595 respondents aged 25 to 64 years. The traits are standardized net traits and bold print indicates significance at the 5% level.

Table 7
Parameter estimates with standard errors in the parentheses [a.]

	GM soybean oil		GM-fed salmon		GM salmon		Knowledge GM	
	No traits[b]	Traits[c]	No traits[b]	Traits[c]	No traits[b]	Traits[c]	No traits[d]	Traits[e]
Constant	**11.15** (2.91)	**12.20** (2.93)	**13.57** (2.88)	**13.20** (2.91)	**12.49** (2.85)	**11.38** (2.89)	0.19 (0.41)	0.34 (0.42)
Age	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	**−0.08** (0.02)	**−0.08** (0.02)	**−0.01** (0.00)	**−0.01** (0.00)
Income	−0.02 (0.44)	−0.15 (0.45)	−0.41 (0.43)	−0.33 (0.44)	0.77 (0.43)	**1.00** (0.45)	0.10 (0.06)	0.08 (0.06)
Gender	0.17 (0.53)	−0.26 (0.55)	−0.58 (0.52)	−0.88 (0.55)	−0.12 (0.52)	−0.63 (0.55)	−0.02 (0.07)	−0.05 (0.07)
Education	0.53 (0.58)	0.61 (0.58)	−0.64 (0.57)	−0.58 (0.57)	0.37 (0.57)	0.34 (0.57)	0.11 (0.07)	0.09 (0.07)
Children	0.57 (0.56)	0.41 (0.56)	−0.40 (0.56)	−0.58 (0.56)	−0.69 (0.55)	−0.84 (0.56)	**−0.15** (0.07)	−0.13 (0.07)
Farm	1.00 (0.51)	0.87 (0.51)	0.33 (0.51)	0.14 (0.51)	0.43 (0.51)	0.26 (0.50)	**−0.25** (0.06)	**−0.24** (0.06)
Environment	0.85 (0.52)	**1.22** (0.54)	0.26 (0.52)	0.50 (0.53)	0.70 (0.52)	0.84 (0.53)	−0.02 (0.07)	−0.02 (0.07)
Naturalness	**16.34** (0.55)	**16.21** (0.54)	**15.52** (0.54)	**15.38** (0.54)	**16.75** (0.54)	**16.55** (0.53)	0.13 (0.07)	0.11 (0.07)
Trust	**−1.74** (0.57)	**−1.70** (0.57)	−1.04 (0.57)	−1.04 (0.56)	**−1.72** (0.57)	**−1.65** (0.57)	0.00 (0.07)	0.01 (0.07)
Knowledge	**−2.88** (0.54)	**−3.01** (0.52)	**−1.95** (0.52)	**−1.97** (0.51)	**−2.70** (0.54)	**−2.76** (0.52)		
Openness[f]		−0.18 (0.25)		−0.05 (0.25)		0.39 (0.25)		0.07 (0.03)
Conscientiousness[f]		−0.48 (0.34)		**−1.08** (0.34)		**−1.18** (0.33)		**0.11** (0.04)
Extraversion[f]		0.08 (0.32)		−0.43 (0.32)		−0.60 (0.32)		0.05 (0.04)
Agreeableness[f]		−0.30 (0.36)		**0.84** (0.36)		**0.83** (0.35)		**−0.15** (0.05)
Neuroticism[f]		**−0.69** (0.31)		−0.42 (0.31)		−0.39 (0.30)		−0.02 (0.04)
n	4,785 [g]	4,785 [g]					1,595	1,595
Loglikelihood	−7,962	−7,947						
Pseudo R^2							0.02	0.03
AIC	15,995	15,994					2,166	2,162
BIC	16,222	16,318					2,220	2,243
LR-test		0.01						0.02
ρ	0.91	0.91						

[a] Bold print indicates significance at the 5% level.
[b] Random effect interval regression model without personality traits.
[c] Random effect interval regression model with personality traits.
[d] Probit model without personality traits.
[e] Probit model with personality traits.
[f] The traits are standardized net traits.
[g] Balanced panel with three observations per respondent.

corresponds well with DeLong and Grebitus (2018), who found agreeableness to be associated with a desire for labelling of GM food and ingredients (DeLong & Grebitus, 2018). Our effect of agreeableness is also consistent with the effect in Lin et al. (2019), who reported a negative association between agreeableness and valuation of GM pork among U.S. consumers. Moreover, agreeableness increased the probability of having correct knowledge. Given the higher GM aversion among those who were aware of the restrictions on the application of genetic modification in Norway, agreeable respondents may be GM averse because they mirror the attitudes of the rest of the society, including the attitudes reflected in public policies. If the environment changes in favor of GM food, it seems plausible that agreeable respondents would be less averse towards GM foods given how their personality contributes to their attitude formation.

Neuroticism was associated with acceptance of GM soybean oil only. This result is consistent with DeLong and Grebitus (2018), who found that consumers with higher scores on neuroticism disagreed with labeling the sugar in soft drinks when it was produced with GM seeds. Peschel et al. (2019) also found that neurotic consumers lost utility from dates labeled as GM-free.

Our results suggest that the acceptance of GM foods is associated with attitudes towards naturalness, trust in public authorities, knowledge, and personality traits. While the personality traits are relatively constant, attitudes towards naturalness are likely to be more fungible and could more easily be changed over time by information about that there is nothing inherently more unnatural about GM foods than conventional foods. Furthermore, given the importance of trust in public authorities, more liberal regulations on the use of GM technologies in agriculture and sales of GM foods could also increase the acceptance. The last conclusion is supported by the higher GM acceptance among those who thought genetic modification was applied in Norwegian agriculture.

There are four main limitations in this study that could be further investigated. First, we used a 20-item version of the Big-Five Inventory. A more complete version based on more items would give a more nuanced measurement of personality and could potentially modify the results. However, it would be difficult to implement in a large survey with a topically wide coverage and many other questions. Second, our survey did not include real economic incentives, and the results may suffer from a hypothetical bias. A meta-analysis of the hypothetical bias problem is provided by, for example, List and Gallet (2001). Third, our measures of attitudes towards naturalness, trust, and environment are based on some questions that may be further developed to test the robustness of our conclusions regarding the effects of attitudes on acceptance. Finally, we did not differentiate between objective and subjective knowledge, which is an interesting issue.

6. Conclusions

We have estimated the effects of socioeconomic variables, attitudes, knowledge, and personality traits on the WTP to avoid GM soybean oil, GM-fed salmon, and GM salmon. We found few significant marginal effects of socioeconomic variables, some effects of knowledge and trust, and strong effects of attitudes towards naturalness. Respondents who found naturalness to be important were willing to pay more than 15% additional premiums for the conventional alternatives.

Even though the average premiums did not change substantially when personality traits were excluded, there were several significant effects of these traits on the WTP premiums for GM soybean oil, GM-fed salmon, and GM salmon. Personality traits were also associated with

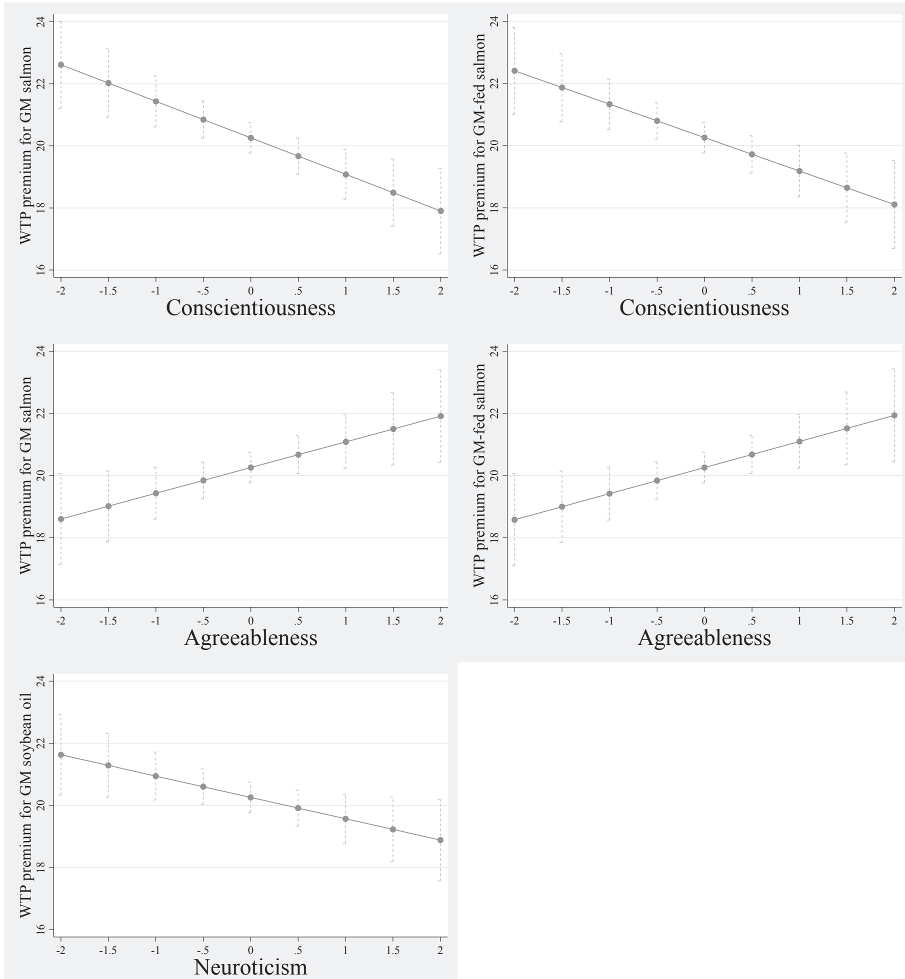

Fig. 2. Marginal effects of personality traits on WTP for GM and GM-fed salmon.
Notes: Based on 1,595 respondents aged 25 to 64 years. The traits are standardized net traits. The observed values of other variables were used in Fig. 2.

Table 8
Estimated WTP to avoid GM alternatives, percentage premiums.

WTP	GM soybean oil	GM-fed salmon	GM salmon
Without personality traits	20.63 (0.98)	18.92 (0.92)	22.33 (1.09)
With personality traits	21.00 (1.07)	19.26 (0.99)	22.78 (1.20)

Notes: Based on 1,595 respondents aged 25 to 64 years. Estimated by the -predict- command after the interval regression analysis in Stata/MP 15.1. Bootstrapped standard errors based on 300 repetitions are given in the parentheses.

knowledge concerning the use of GM technologies in Norwegian agriculture. These associations suggest that personality traits are correlated with some of the heterogeneity among respondents, and this source of heterogeneity needs to be further studied.

Our results are useful for policy makers, campaigners, and others interested in GM foods. We found moderate effects of stable personality traits and strong effect of attitudes towards naturalness. Information and changes in regulations, which are based on solid scientific evidence and emphasize that there is nothing inherently more unnatural about GM foods than conventional products, are likely to increase the acceptance of GM foods over time.

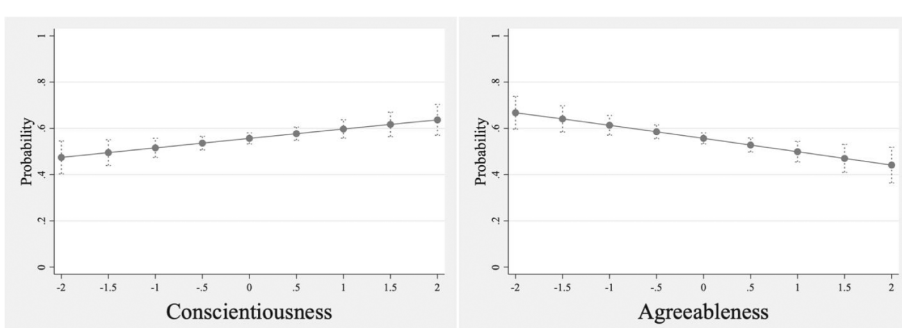

Fig. 3. Marginal effects of personality traits on knowledge.
Notes: Based on 1,595 respondents aged 25 to 64 years. The traits are standardized net traits. The observed values of other variables were used in Fig. 3.

Acknowledgements

The authors wish to thank Norwegian Institute of Bioeconomy Research for providing us with the data, Geir Gustavsen for his assistance with the methodology, and Albert Satorra for his guidance on constructing the personality traits. We are also grateful to the editor, two anonymous reviewers and colleagues at the Chair of Marketing and Consumer Research in the School of Management at Technical University of Munich for their useful comments.

Funding

No external funding was provided for this research.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2019.103825.

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