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Household preferences when purchasing handwashing liquid soap: A choice experiment application

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ABSTRACT

Limited information is provided on the potential impacts of ingredients in consumer products to assist individuals to purchase household products. This study applied the choice experiment technique to examine the preferences of 385 New Zealand households on their purchasing choice of liquid soap for handwashing. Results from the choice experiment survey, conducted in December 2016 to March 2017, indicated that a typical respondent from the full sample would be willing to pay premium prices for a bottle of liquid soap that is certified to be environmentally friendly (NZ$3.20), hypo-allergenic (NZ$2.90), contains natural ingredients (NZ$2.10), and has antibacterial properties (NZ$1.40). However, by dividing the full sample into four latent classes, a typical respondent in one class would pay NZ$1.88 to avoid the antibacterial activity. This study highlights the importance of accounting for preference heterogeneity across latent classes or respondent sub-groups to better understand preferences and awareness of ingredients in liquid soaps, such as antibacterial chemicals, that can pose environmental and health risks.

1. Introduction

The topic of consumer purchasing behaviour has gained increasing attention over the past decades (Backhaus et al., 2007; Gabbott and Hogg, 1994; Kotler and Keller, 2012). More recently, consumers are becoming more concerned about reducing the impacts of their daily activities on the natural environment (Bleda and Valente, 2009; Huynh et al., 2018). Foodstuffs, furniture and personal care products may contain ingredients that pose a risk making consumer products an important factor of our long-term pressure on the environment (Bougherara and Combris, 2009; Cai et al., 2017; Chang et al., 2018). For example, liquid soap for handwashing may contain multiple ingredients that can affect human and environmental health when released into the waste stream (Kalyvas et al., 2014; Tremblay et al., 2013). Liquid soaps advertised as having antibacterial properties may contain active ingredients like triclosan, a broad-spectrum antimicrobial agent commonly found in many consumer and personal care products, including toothpaste (Aiello et al., 2007; Perez et al., 2013). Triclosan is a persistent and biologically active chemical that can cause microbial resistance, dermal irritations and endocrine disruption and is considered an emerging contaminant (Yueh and Tukey, 2016).

Households and individuals have been found to be willing to pay a premium price for consumer products such as food, furniture, orange juice, timber and wine that have been produced using practices that reduce environmental impacts (Aguilar and Vlosky, 2007; Bougherara and Combris, 2009; Cai et al., 2017; Laroche et al., 2001; Lombardi et al., 2017; Sellers-Rubio and Nicolau-Gonzalbez, 2016; Tait et al., 2016). Other studies provide evidence that households would pay more for consumer products with reduced health risks (Veronesi et al., 2014; Wang et al., 2018). While there is some evidence that households increasingly value the reduction in health and environmental risks for a variety of household products, little is known about the purchasing preferences of consumers on the health and environmental impacts of liquid soap.

The *choice experiment* (CE) technique was developed in the field of environmental economics in the mid-1990s (Boxall et al., 1996) to indirectly obtain data on the preferences of individuals for

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changes in the provision of environmental goods and services. This quantitative technique has been used for various food, environmental and health valuation studies, including food policy, biodiversity conservation, water pollution reduction, remediation of contaminated environments and health systems (Balcombe et al., 2010; Franken and Koolman, 2013; Huynh et al., 2018; Veronesi et al., 2014; Yao et al., 2014). The principle behind CE is based on the theory of value developed by Lancaster (1966) and random utility models (RUMs) described in McFadden (1974). RUMs are discrete choice econometric models. They assume that a respondent has a perfect discrimination capability, whereas an analyst does not have complete information and should account for uncertainty (see Manski and Lerman, 1977).

The objectives of this study were to: (1) identify the factors that influence consumer purchasing choice of liquid soap; (2) analyse consumer preferences and how trade-offs are made across different factors when choosing liquid soap; (3) estimate the willingness of households to pay for the changes in the provision of liquid soap attributes; and (4) explore the awareness of respondents on emerging contaminants. The survey-based CE technique (Carson and Louviere, 2011) was used to understand and measure the purchasing preferences of a sample of New Zealand households on their choice of liquid soap for household use. To the best of our knowledge, this is the first CE application to examine the preferences of households on liquid soap with the intention of indirectly eliciting respondents' awareness and views on emerging contaminants.

2. Methods, design of experiment and models

The study employed four steps: (1) scoping exercise to determine the focus of the research and identify the factors that should be included in the choice experiment; (2) focus group discussions to finalise the design of the CE survey; (3) administration of an online CE survey to collect household data; and (4) survey data analysis using econometric models.

The scoping exercise involved reviewing related literature and discussing the topic with New Zealand toxicologists studying emerging contaminants. This step guided the research team to focus on liquid soap for handwashing because (1) New Zealand product manufacturers are required to list the ingredients on the product label; (2) some liquid soaps contain anti-bacterial and anti-fungal contaminants (e.g. triclosan) while others do not; and (3) the project team considered that most New Zealanders were familiar with liquid soaps.

2.1. Identification and development of attributes in the choice experiment

To identify the attributes for inclusion in the CE, two focus groups were identified in the North Island of New Zealand in mid-2016. Twelve participants were recruited through the parent-teacher association of a primary school for the first focus group and nine people recruited through a community organisation primarily composed of parents for the second. These focus groups helped identify the five key attributes in the CE. Further details on how the attributes were identified are presented in Appendix A.

The identified five attributes from the focus groups and the sixth attribute (i.e. 'product certified' or 'eco-labelling') based on the literature (e.g. Liu et al., 2017) are presented in Table 1. Each attribute in the CE was assigned with either two or three levels of provision. The first represents the base attribute level or the current level of provision. From the base level, we identified a feasible expansion to a second and to a higher third level. The 'Antibacterial' attribute was assigned with a base and a second level, 'No claims' and 'Has claims', respectively. The attribute has been included in the CE to serve as proxy for emerging contaminants. 'Allergy' has a base level where a household respondent is not worried that the liquid soap could trigger a skin allergic reaction for at least one household member while the other level is concerned that an allergic reaction could be triggered. 'Natural ingredients' was assigned with 'Does not claim to have' and 'Claims to have'. This was envisioned to explore if a typical respondent would prefer natural ingredients that do not harm the environment. The 'Fragrance' attribute was included to demonstrate that while some soaps have minimal to no scent, others have either mild and pleasant or strong and pleasant scent. The 'Product certified' attribute was used to indicate whether the liquid soap is certified to be eco-friendly or is guaranteed by an independent entity to have less impact on the environment compared with conventionally produced product. For the 'Price' attribute, three levels of liquid soap prices were identified as NZ$1.50, NZ$4.50 and NZ$7.50 based on interviews and New Zealand supermarket prices in 2016.

2.2. Design of choice experiment

CE is a survey-based technique that can analyse preferences of individuals and understand how they make trade-offs across competing scenarios. It helps to characterise an economic good (e.g. liquid soap) based on its attributes. CE models the decision process of an individual that is made in a particular context or contexts, such as focusing on the six attributes of liquid soap: natural ingredients, price, allergy free, odour, certification and antibacterial properties. In the CE valuation process, we do not estimate the overall value of the product, but we estimate the value of the changes in the provision of key product features by providing survey respondents with a few choice situations. This enables multiple attributes to be simultaneously varied with the use of an experimental design e.g. orthogonal design (Carson and Louviere, 2011). More details on the theory behind the estimation of values

Table 1
Attributes and attribute levels used in the design of choice experiment.

Attribute	Levels
Antibacterial	No claims
	Has claims
Allergy	Not worried
	Concerned
Fragrance	No/Minimal scent
	Mild and pleasant scent
	Strong and pleasant scent
Natural ingredients	Does not claim to have
	Claims to have
Product certified	Not certified to have low impact on the environment
	Third party certified to be friendly to the environment – 'eco-friendly'
Price (NZ$/bottle)	1.50, 4.50, 7.50

can be found in Tait et al. (2016).

The approach for populating CE choice situations with attribute levels is based on an experimental design that is optimised following a certain criterion (e.g. orthogonality, Bayesian D-efficiency, optimal orthogonality in the difference – refer to Scarpa and Rose (2008) for a description of design criteria). Yao et al. (2015) provided evidence that the Bayesian D-efficiency criterion offers several advantages (e.g. improved statistical efficiency of models and improved behavioural efficiency of respondents) compared with other design criteria. Following Yao et al. (2015), we employed the Bayesian D-efficiency criterion that makes use of an optimised experimental design based on a set of prior information from 11 selected respondents who completed a pilot survey with choice tasks optimised following the orthogonality criterion. Responses from the pilot respondents provided prior information to construct the Bayesian D-efficiency fractional factorial experimental design generated using NGeneTM (ChoiceMetrics, 2018) to populate the choice situations in the survey. Choice data collected from pilot respondents were not included in the analysis as an orthogonal design was used to create those choice situations.

The experimental design that we optimised for Bayesian D-efficiency consisted of 72 unique choice scenarios which were distributed into 36 choice situations grouped into four blocks by using a blocking variable (Appendix B). Having four blocks gave rise to four different versions of the questionnaire, each containing nine choice situations. We elected to use nine choice situations per respondent based on the lead author's experience in conducting CE surveys. Each choice situation had a pair of alternatives that a respondent evaluated (Fig. 1). When a respondent selected the preferred alternative from among two, she/he implicitly revealed

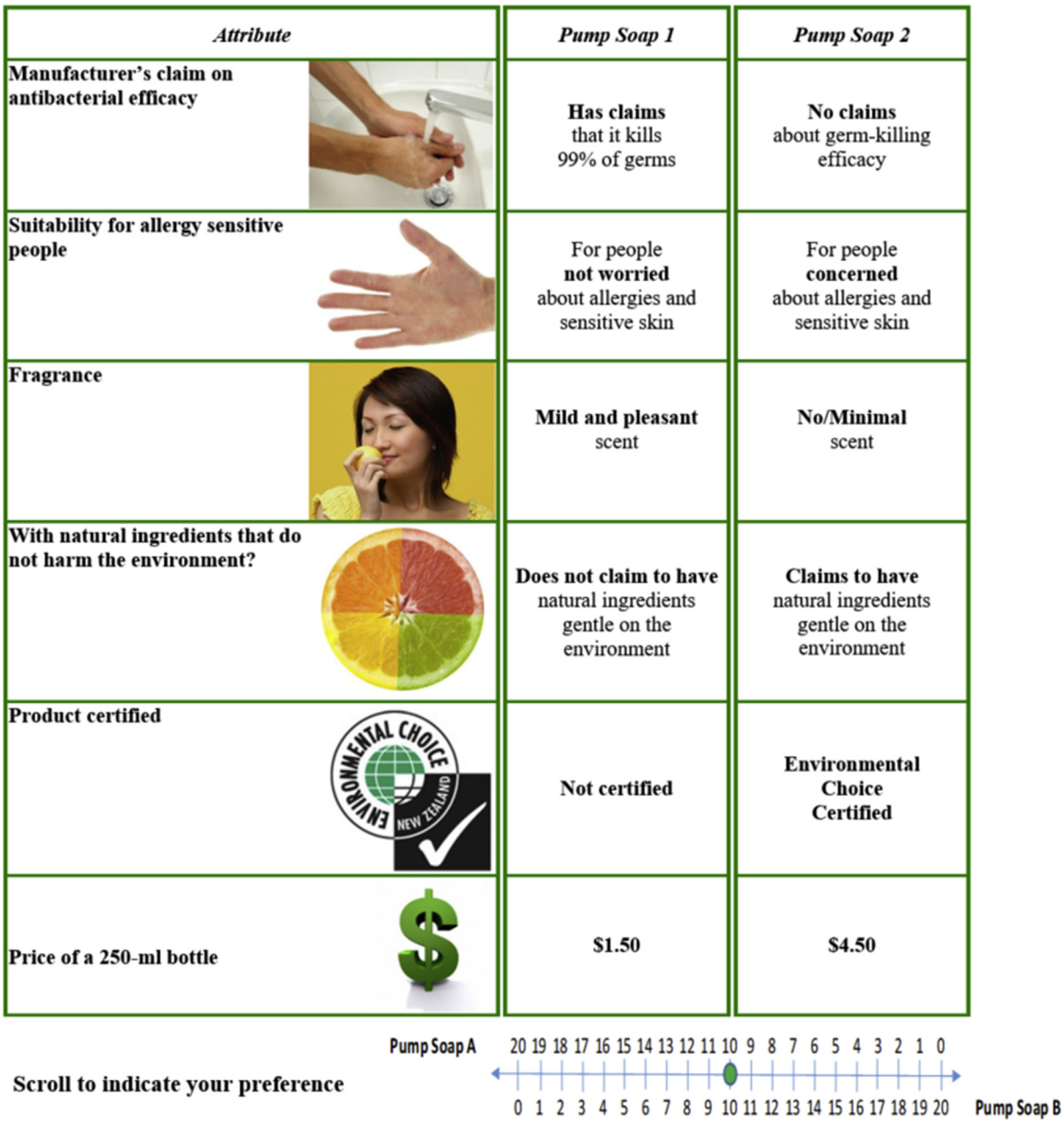

Fig. 1. An example of a choice situation used in the online survey.

her trade-offs between the levels of attributes in the alternatives shown in a choice task.

As shown in Fig. 1, each choice task consisted of six attributes. Following the choice experimental design in Appendix B, the nine unique choice situations have varying attribute levels to enable trade-off analysis. For example, the price attribute of $1.50 for Pump Soap A and $7.50 for Pump Soap B for the choice situation in Fig. 1, would change in the next choice task to say $4.50 and $1.50, respectively. Each respondent evaluated the two alternatives in each choice task then chose their preferred alternative by indicating the number of times out of 20 purchases they would buy one option product relative to the other product. Choosing one alternative 20 times out of 20 indicated certainty that it was the preferred alternative. Choosing 10 out of 20 indicated indifference where each alternative had a probability of 50% of being selected.

Each respondent was presented with nine choice situations. To avoid attribute ordering bias (Kjær et al., 2006), the ordering of the attributes within each choice alternative was randomised in the online survey. The valuation scenario of the CE questions was tested through a series of questions with seven selected people in a region in the South Island of New Zealand in mid-2016. Responses were used to provide clarity on the design of questions on the choice of liquid soaps and factors that influence choice.

2.3. Econometric modelling approaches

Two types of econometric approaches were used in this study: the elicited choice probability approach and the latent class logit approach (Blass et al., 2010; Carson and Louviere, 2011; Train, 2008). The elicited choice probability approach was first empirically implemented by Blass et al. (2010) and derived from the econometric proposition of Manski (1975). Manski (1999) argued that stated choices may differ from actual choices because researchers provide respondents with different information than they have when facing actual choice problems. The approach has been used to pose a set of finite scenarios, where respondents are given a subset of the information they would have in actual choice settings. However, there can be a large number of scenarios and they all cannot be included in a survey. Therefore, stated choices cannot be more than point predictions of actual choices. Elicitation of choice probabilities overcomes the inadequacy of stated-choice analysis by permitting respondents to express uncertainty regarding their behaviour in incomplete scenarios.

To analyse elicited choice probability survey data, we employed the fractional logit and the latent class logit models. The *fractional logit model* is based on a quasi-likelihood estimation as described by Wedderburn (1974) and generalised by McCullagh (1983). The dependent variable for this approach is assumed to be a proportion in the (0,1) interval, which made it suitable for the nature of the elicited choice probability data. The fractional logit model accounted for the uncertainty in the choice decision of the respondents, but does not account for the correlation across the panel of nine responses of each respondent. This restrictive model served as our base model. The second model was the *quantile regression model*, which was estimated following a median regression approach. Reported standard errors and t-statistics from this model are asymptotically valid under regression model issues, such as heteroskedasticity and intra-cluster correlation (Parente and Santos Silva, 2016). Similar to fractional logit, the dependent variable was assumed to be a proportion between 0 and 1. But unlike fractional logit, quantile regression can account for the correlation in preference across the panel of nine choice situations that each respondent evaluated. This made the quantile regression approach more appropriate as it accounted for the panel nature of the elicited choice probability data. This approach therefore provided a richer characterization of the choice data, allowing us to consider the impact of a covariate on the entire distribution of dependent variable (the choice variable), not just its conditional mean.

Coefficient estimates from fractional and quantile regression models can be used to calculate willingness to pay (WTP) for higher attribute levels for the pooled sample using the Krinsky and Robb (1986) parametric bootstrapping technique. We also used the quantile regression model to analyse the preferences by socio-economic sub-groupings to explore heterogeneity in preferences across sub-groupings within the sample. This was done by dividing the full sample by socio-economic subgroups (e.g. male versus female, age <45 versus age ≥45 years old) similar to the approach employed by Blass et al. (2010).

Each respondent or each group of respondents could have a unique set of preference and there was a need to account for heterogeneity of preferences across a sample of respondents. In this study, we have accounted for heterogeneity of preferences across respondents and respondent groups within the sample using the Latent Class Logit (LCL) model (Wedel and Kamakura, 2000). This model enables the classification of respondents into a set of classes that was not directly observed by the analyst (Greene and Hensher, 2003). The LCL model is an econometric model that enables a "model-based clustering" approach that derives clusters using a probabilistic model that describes the distribution of the choice data. Instead of an analyst finding clusters with some arbitrary chosen distance measure (e.g. cluster analysis), using the discrete choice LCL model (i.e. dependent variable either 0 or 1) enables class memberships to be modelled up to a probability using a class assignment model (Train, 2008). We also employed a panel specification to account for the panel nature of the discrete choice data (Econometric Software, 2014). To identify the optimal number of latent classes, an iterative approach was employed where 10 model runs (2–11 latent classes) were undertaken to evaluate the goodness of fit of each latent class model specification. For comparisons of fit to the data, and to identify the most applicable number and types of latent classes, we used two criteria. The first criterion is the minimum Akaike Information Criterion (AIC) approach, where the latent class logit model specification with the lower AIC statistic was considered to provide better model goodness of fit (Boxall and Adamowicz, 2002; Swait, 1994). The second criterion was based on the richer interpretation of the survey data (Ruto et al., 2008), where the latent class model that provided the most meaningful explanation of the preferences of respondents was given a higher weight.

2.4. Design and administration of the survey questionnaire

The online survey questionnaire administered in the study was developed following the recommended practices described in Dillman et al. (2014). The questionnaire included questions on the use of liquid soaps, nine choice situations for the CE and socio-economic characteristics. The online questionnaire was made available to survey respondents between December 2016 and March 2017. Over this four-month period, electronic bulletin boards of selected research institutions, government agencies and business organisations located in the North Island were used to invite people to join the survey. Simultaneous invitations were extended using social media (i.e. Facebook) to further recruit respondents from non-research, governmental and business organisations.

The online survey also included questions to understand the approximate annual budget of households for liquid soap. For example, (1) *how many times was liquid soap bought over the last* 12 months?; and (2) *how much was spent on their last purchase of liquid soap?* Questions on whether respondents read the list of ingredients on the label and awareness of health and environmental

Table 2
Distribution of households by education and income (survey data versus New Zealand).

	Survey sample (%)	New Zealand population (%)
Gender[a]		
Female	83	51
Age[b]		
18 (15) to 24 years old[c]	8	18
25 to 44	26	32
45 to 64	46	32
65+	20	18
Educational attainment [d]		
Primary and secondary education	28	48
Trades certificate/Post school diploma	15	31
Tertiary and higher	57	21
Total (%)	100	100
Ethnicity [e]		
NZ European/European migrant	82	66
Māori	7	14
Asian	5	11
Pacific Island	1	5
Others	5	4
Total (%)	100	100

[a] Adapted from the 2013 New Zealand population census data accessed at http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-national-highlights/age-and-sex.aspx.
[b] 2013 NZ age distribution accessed at https://www.health.govt.nz/our-work/populations/maori-health/tatau-kahukura-maori-health-statistics/tatauranga-taupori-demographics/age-structure.
[c] The age range for survey data was 18–24 years old while the NZ data was 15–24 years old.
[d] 2015 New Zealand data accessed at http://www.educationcounts.govt.nz/.
[e] Adapted from 2013 New Zealand population census data accessed on 14 March 2017 at http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE8021#.

impacts of liquid soap ingredients were also included. The sources of respondents' information were ascertained by asking them to select from a list (e.g. internet, mass media, medical professionals); an opportunity was also provided for them to specify sources that were not on the list. Respondents were also asked about the brand of liquid soap they purchased to inform our analysis as to whether or not they were buying soaps marketed as eco-friendly.

3. Results and discussion

3.1. Survey data summary and results

A total of 419 online surveys were collected. After filtering invalid survey responses (e.g. incomplete survey), the number of valid respondents was reduced to 385. About half (47%) of the valid respondents were recruited via social media, 25% via posting on electronic bulletin boards, 17% from the set of New Zealand based respondents listed on MailChimp[1] and 8% were from 'snowballing approach' where an option was provided for each respondent at the end of the survey to share the survey link to their peers.[2]

A significantly higher proportion of the 385 respondents had a tertiary education (57%) compared to the overall 2015 New Zealand population (21%) (Table 2). In terms of income, 324 respondents indicated their annual household income range and about 45% of them earned more than $70,000. As the inflation rate between 2013 and 2017 was only about 3%,[3] the income ranges from the 2017 survey data remained comparable with the 2013 census data (Statistics New Zealand, 2014). The proportion of respondents with annual household incomes greater than $60,000 (54%) was virtually the same as the proportion of 53% in the New Zealand census. The sample had a higher proportion of New Zealanders of European descent and European migrants (82%), but lower proportions (13%) of Māori (indigenous people of New Zealand), Asian and Pacific Islanders compared to the 2013 Census population (Table 2). About 83% of the survey respondents were female, while the New Zealand population had 51%. In terms of age distribution, the sample had a greater proportion of 45 to 64-year olds while having a lower proportion of 25 to 44-year olds. With the above differences between the sample of respondents and the New Zealand population, we do not claim that we have a representative sample of the New Zealand population. The results from this study would therefore be specific to the sample of respondents studied here.

Our survey data suggested that more than half (53%) of the respondents used liquid soap 99% of the time, 23% used it 75% of the time, 24% reported using it at most 50% of the time. Results also indicated that the median household purchased $42 worth of liquid soap over the last 365 days. The average purchase amount of $53, which is slightly higher than the median, suggested that a typical household spent $1 per week for liquid soap. About half (51%) of the respondents spent between $10 and $50 per year, a quarter (27%) spent $51 to $100 and 14% spent more than $100 per year. The latter group can be considered as the most frequent users of liquid soap. This is supported by a significantly positive correlation between liquid soap budget and liquid soap being used in 99% of handwashing.

Respondents were asked to report the brand of liquid soap they used in their household and were given the option to report multiple brands. We categorised different brands into 'regular' (e.g. Palmolive, Health Basics and Dettol) and 'eco-friendly' (e.g. Ecostore and Only Good). About 63% used regular, 12% used eco-friendly, 13% used both types, while the rest did not report the brand they used. Twenty nine percent of respondents reported that they read the list of ingredients on the soap, while 36% reported being aware of negative health impacts of liquid soaps, such as skin allergic reactions (e.g. dry skin, skin cracking and dermatitis) associated with some ingredients.

In terms of sources of information on health impacts of liquid soap, the four main sources stated were: (1) online browsing (29%);

[1] https://login.mailchimp.com.
[2] Given the approach of recruiting respondents, analytic results are specific to the sample of respondents studied here.
[3] http://www.rbnz.govt.nz/monetary-policy/inflation-calculator

(2) family, relatives, friends and colleagues (24%); (3) self-experiences or self-realisations (20%); and (4) the mass media – TV/radio/magazine/newspaper (18%). A small proportion (9%) of respondents relied on medical professionals (e.g. dermatologists) and access to scientific papers.

For information on environmental impacts of liquid soap, the four main sources were similar to those seen for health impacts, but a slightly larger proportion of respondents relied on the internet (36%), family and friends and mass media (23%), self-awareness or personal experiences (16%) and only 4% relied on medical professionals (e.g. dermatologists) and scientific papers.

In a section of the online questionnaire, respondents were provided 17 product features (e.g. natural ingredients, eco-friendly and allergy free) that they could consider when choosing the liquid soap for household use. Six of these features were included in the CE and respondents were asked to rate each feature according to five levels of importance with the rating of '5' as the most important (Fig. 2). If a respondent was unsure about the ranking, he or she could report 'unsure'. Five percent of the sample gave at least one 'unsure' response.

By considering only the respondents who gave ratings between 1 and 5, we calculated the average ratings (Fig. 2). While considering the top six features with average ratings greater than 3.50 we found that 'not animal tested' (3.80), 'allergy free' (3.80) and 'performs as expected' (3.74) were rated the highest. The features 'pleasant odour' (3.40) and 'eco-friendly' (3.14) received average ratings greater than 3. The feature 'antibacterial' received the lowest average rating (2.78) amongst the six attributes (in green colour bars in Fig. 2). Almost half (46%) of the respondents gave it the lowest ratings of either 1-not important or 2-slightly important, while 34% regarded it as either 4-very important or 5-highly important. There was a bimodal rating distribution where one group did not like the antibacterial feature while another group preferred its presence in liquid soaps. The seven respondents who gave ratings of 1 and 2 wrote in the comments section of the online survey that they "did not want antibacterial" or "are avoiding antibacterial". And finally, the features 'promotion', 'packaging' and 'generic branding' received the lowest ratings.

3.2. Econometric model estimates

3.2.1. Analysis of the full sample using fractional and quantile regression models

Econometric models were used to analyse the collected choice data set, which consisted of 6930 choice options evaluated by 385 respondents (full sample). Estimates from both fractional logit and quantile regression models showed statistically positively significant coefficient estimates for 'With antibacterial claim', 'Hypoallergenic', 'With natural ingredients', and 'Certified' (Table 3). These suggested that a typical respondent considered those four factors positively when buying liquid soap for household use. Both regression models provided coefficient estimates with the expected positive or negative signs. They also demonstrated acceptable model goodness of fit as indicated by the ρ and p-value statistics (Table 3).

Using the economic principle of the marginal rate of substitution, we calculated the WTP for each attribute by taking the ratio of the estimated coefficient for each attribute level with the 'Price' coefficient. The mean marginal WTP values and corresponding 95% confidence intervals were calculated using the Krinsky and Robb (1986) parametric bootstrap method with 5000 draws. WTP estimates from the quantile regression model suggested that a typical respondent would be willing to pay $1.40 ($0.72 to $2.21) for a 250-ml bottle of liquid soap if it has been labelled 'Antibacterial'

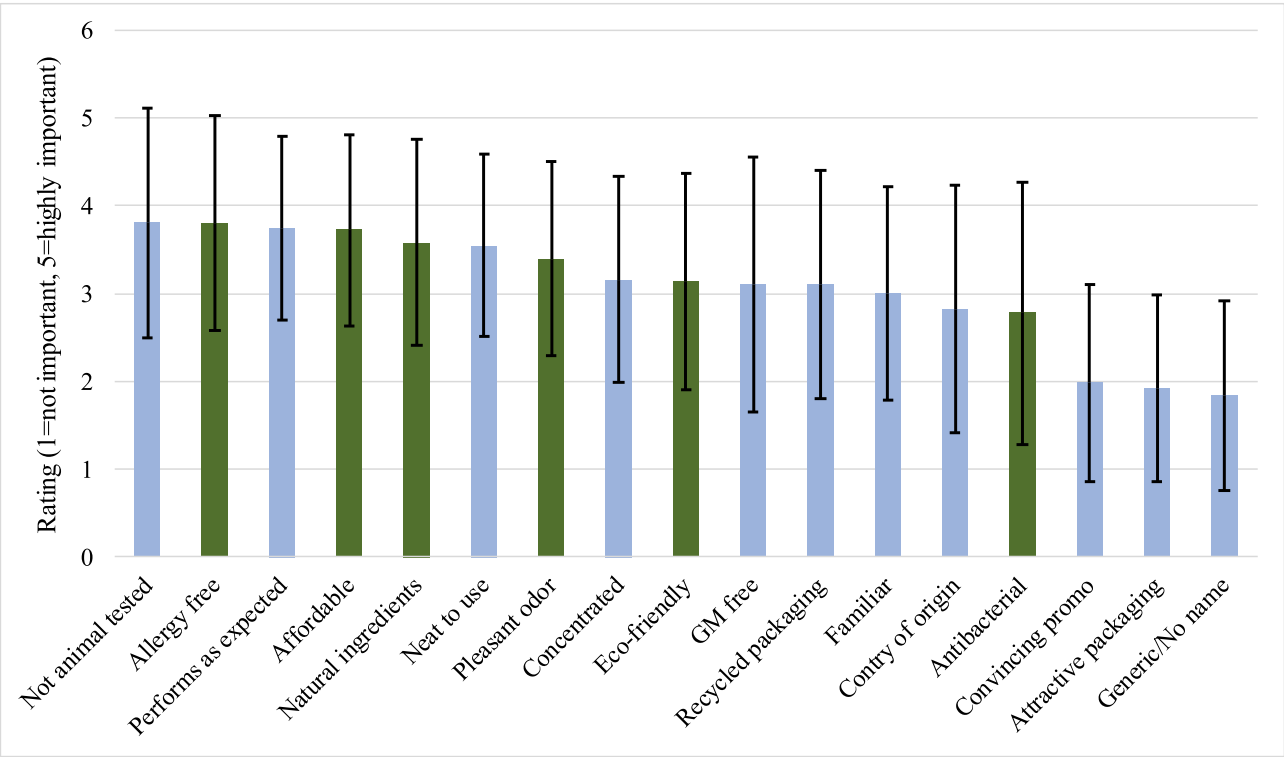

Fig. 2. Average rating for each factor (1 = not important; 2 slightly important; 3 = important; 4 = very important; 5 = highly important) (n = 385). Green bars indicate product features or attributes that have been included in the choice situation. Note: Standard deviation bars (I) in the graph indicate the spread of the distribution of ratings for each attribute.

Table 3
Parameter estimates from fractional logit and quantile regression models.

Dependent variable: Probability of choosing alternative 1	Fractional logit	Quantile/Median regression
With antibacterial claim	0.073***	0.035***
	(0.014)	(0.009)
Hypo-allergenic	0.173***	0.073***
	(0.014)	(0.011)
Mild and pleasant scent	−0.032	−0.015
	(0.044)	(0.021)
Strong and pleasant scent	−0.059*	−0.030*
	(0.026)	(0.014)
With natural ingredients	0.124***	0.053***
	(0.015)	(0.008)
Certified	0.158***	0.080***
	(0.017)	(0.010)
Price	−0.058***	−0.025***
	(0.006)	(0.004)
Intercept	−0.002	0.495***
	(0.013)	(0.006)
Number of choices	6930	6930
Number of respondents	385	385
ρ^2	0.0767	0.2462

Note 1: Numbers enclosed in parentheses are standard errors.
Note 2: *, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.

(Table 4). The other attributes of having natural ingredients and being hypo-allergenic were valued even higher by a typical respondent as reflected in the WTP value of $2.10 and $2.90, respectively. Having 'product certification' was the most valued feature as indicated by having the highest mean marginal WTP value of $3.20, suggesting that this feature had the greatest net positive impact amongst the five features (Fig. 3). Interestingly, the attribute strong and pleasant scent had a negative WTP (-$1.01) suggesting that a typical respondent in the full sample would pay to avoid a liquid soap with a strong scent. The coefficient for the mild and pleasant scent attribute was not statistically significant implying that if we included this attribute with the set of attributes above, a typical respondent would not have considered this factor in their purchasing decision.

3.2.2. *Quantile regression estimates by sub-samples and latent class logit model estimates*

Following Blass et al. (2010), an analysis of the elicited choice probability data by socio-economic sub-samples was undertaken to explore if household characteristics had a systematic effect on preferences and expectations. The sample splits were completed by age, income, gender, education, self-rated understanding of survey questions, antibacterial importance and ethnicity. This approach allowed an exploration of possible bi-modal distribution of preference for the antibacterial attribute and other attributes. Focusing on the antibacterial attribute, it was found that respondent sub-samples with higher income level, higher education, placing low importance on the antibacterial feature, and the subgroup who were not New Zealand-born Europeans, did not significantly value having an antibacterial feature in liquid soaps (Appendices C1 and C2).

To further investigate the four socio-economic sub-samples of respondents who did not significantly value the antibacterial feature in liquid soaps, class membership indicator variables were included in the estimation of 10 latent class logit models with a varying number of latent classes. Based on the criterion of minimum Akaike Information Criterion that successfully converged, the model with five latent classes is the optimal model (AIC/N of 0.804). However, the model with four latent classes came as a very close second with AIC/N of 0.806 (Appendix D). The model with four latent classes also better described the bimodal distribution of preference for the antibacterial attribute. It also enabled a much richer interpretation of the survey, making it the more suitable model. This criterion for selecting the appropriate number of latent classes has been employed in previous applications of the latent class approach e.g. Ruto et al. (2008).

Latent Class 1 represented a group of respondents that accounted for 30% of the 385 respondents in the full sample (Table 5). This price sensitive group did not significantly value the antibacterial feature. However, a typical respondent in this group placed a high value on a liquid soap with product certification and natural ingredients and would be willing to pay $1.70 and $2.09 respectively for those attributes (Appendix E). The group also placed significantly lower importance (relative to Latent Class 4) on the antibacterial feature based on the class probability model coefficient estimate of 1.47 (Table 5). Latent Class 2 (13% of the

Table 4
Mean marginal willingness to pay (WTP) and 95% confidence intervals (CI).

Attribute	Fractional logit			Quantile/Median regression		
	Mean WTP	95% CI		Mean WTP	95% CI	
		Lower bound	Upper bound		Lower bound	Upper bound
With antibacterial claim	1.25	0.81	1.73	1.40	0.72	2.21
Hypo-allergenic	2.96	2.17	4.15	2.90	1.74	4.78
Mild and pleasant scent	–	–	–	–	–	–
Strong and pleasant scent	−1.01	−1.67	−0.17	−1.20	−2.04	−0.09
With natural ingredients	2.13	1.43	3.11	2.10	1.26	3.45
Certified product	2.71	1.86	3.95	3.20	2.05	5.11

Note: WTP mean and confidence intervals estimated using Krinsky and Robb (1986).

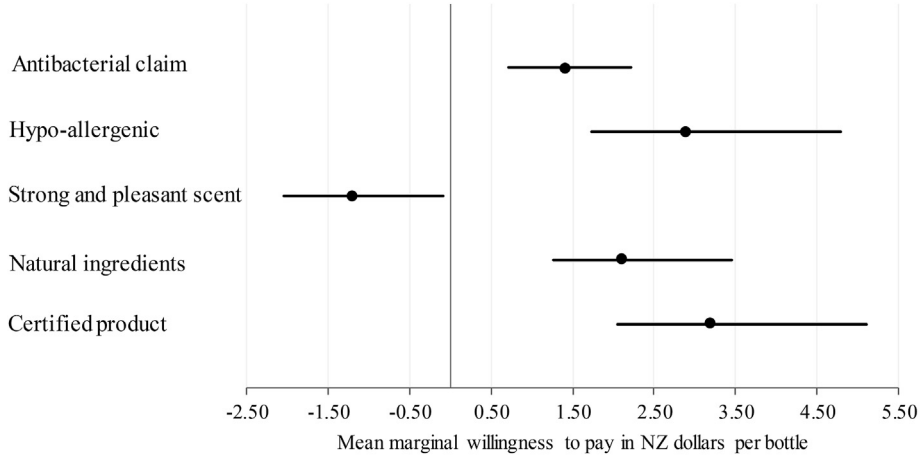

Fig. 3. Mean marginal willingness to pay (with lower and upper bounds of the 95% confidence intervals of WTP) for the five liquid soap features. This figure illustrates the quantile regression estimates presented in Table 4.

respondents) placed the highest value on having an antibacterial property followed by being certified and then, having natural ingredients. This latent class was not influenced by price.

Latent Class 3 (29% of respondents) was the only group that had a negative coefficient for 'With antibacterial claim' (Table 5) and a typical respondent in this group would pay $1.88 ($0.70 to $4.35) to avoid purchasing a liquid soap with antibacterial label (Appendix E). This price sensitive group tended to avoid both mildly and strongly scented soap products (mean WTP of -$5.71 and -$5.26, respectively), which indicated their preference for minimal fragrance. Latent Class 4 represented a group which preferred a hypo-allergenic soap with pleasant scent that was certified and has an antibacterial feature. Similar to Latent Class 2, Latent Class 4 was not price sensitive and therefore we did not calculate the corresponding WTPs for those attributes.

The latent class logit model allowed the accounting for heterogeneity of preference across groups, which enabled more meaningful interpretation of econometric modelling results than

Table 5
Estimates from the latent class logit model with four Latent Classes.

	Class 1	Class 2	Class 3	Class 4
Utility parameters				
With antibacterial claim	0.196	1.846***	−0.259*	0.309*
	(0.162)	(0.536)	(0.140)	(0.177)
Hypo-allergenic	0.204	−0.239	−0.053	1.979***
	(0.244)	(0.345)	(0.147)	(0.301)
Mild and pleasant scent	0.540	1.522	−0.840*	1.380**
	(0.593)	(0.943)	(0.444)	(0.570)
Strong and pleasant scent	0.285	0.195	−0.751***	1.018***
	(0.316)	(0.497)	(0.256)	(0.346)
With natural ingredients	0.709***	0.810*	0.380***	0.240
	(0.224)	(0.427)	(0.113)	(0.178)
Certified	0.872***	1.032***	0.171	0.958***
	(0.276)	(0.380)	(0.161)	(0.210)
Price	−0.424***	0.070	−0.145**	0.034
	(0.080)	(0.120)	(0.057)	(0.074)
In class probability model estimates				
Constant	−0.902	−0.302	0.749	*Reference*
	(0.879)	(0.984)	(0.664)	*class*
Higher education	−0.004	−0.036	−1.010**	
	(0.466)	(0.576)	(0.475)	
Lower antibacterial importance	1.473**	−0.790	0.108	
	(0.600)	(0.584)	(0.460)	
Income >70 k	0.100	−0.120	−0.136	
	(0.461)	(0.584)	(0.463)	
NZ-born European	−0.196	−0.046	−0.342	
	(0.498)	(0.770)	(0.527)	
Average class probability	0.301	0.128	0.293	0.278
Number of respondents	385			
Number of observations analysed	3465			
Number of choice observations dropped due to equi-probability [Note 3]	175			

Note 1: Numbers enclosed in parentheses are standard errors.
Note 2: *, **, *** indicates significance at the 90%, 95%, and 99% levels, respectively.
Note 3: As we collected elicited choice probability data, respondents had the option of expressing indifference across two options (i.e. having 50-50 chance of being selected). When choice probability (dependent variable values between 0 and 1 (e.g. 0.1, 0,5, 0.8)) was converted to discrete choice data (dependent variable either 0 or 1), to allow latent class logit analysis, choice observations with the '50-50 chance' had to be dropped from the latent class analysis. Excluded choice observations accounted for about five percent of the full sample.

accounting for individual preference heterogeneity using the quantile regression model. Survey data collected from the full sample suggested that a typical respondent would pay premium prices for a bottle of liquid soap that was certified to be eco-friendly, hypo-allergenic, contained natural ingredients, and had antibacterial properties. Results from the latent class logit model, which divided the full sample into four latent classes, indicated that respondents would benefit from getting more information on the impacts of antibacterial ingredients (e.g. triclosan) on human health and the environment. Latent class logit model estimates showed that Latent Classes 2 and 4, which accounted for 41% of the respondents, valued antibacterial ingredients in liquid soap suggesting that a significant proportion of the sample were less aware of the environmental consequences of emerging contaminants that are being released into waterways. However, 29% (Latent Class 3) who preferred to avoid anti-bacterial liquid soap may have a variety of avoidance reasons, such as awareness of the negative impacts of antibacterial chemicals or avoiding killing off good bacteria which can benefit the immune system. A large majority of respondents (72%) (Latent Classes 1, 2 and 3) chose to have natural ingredients that have minimal environmental impacts. Similarly, 71% of respondents (Latent Classes 1, 2 and 4) sought to have environmental certification, indicating that these respondents preferred to be assured that the liquid soap had been produced sustainably and had minimal environmental impact. Latent Class 3 preferred to avoid pleasantly scented liquid soap which was opposite to the preference of Latent Class 4 who strongly preferred either mild or strong and pleasant scents, as well as being hypo-allergenic.

4. Conclusions

To the best of our knowledge, this study is the first CE application to analyse the preferences of survey respondents in choosing a household product (i.e. liquid soap) that enabled the estimation of willingness to pay for eco-friendliness, eco-labelling and reduction in health impacts while indirectly accounting for views on emerging contaminants (through the antibacterial attribute). The econometric models (fractional logit and quantile regression) used to analyse the full sample accounted for the probabilities in the elicited choice responses, as well as the bimodal distribution in preference of respondents. This probably represents the first application of this type of econometric modelling for non-food household products.

Results from the analysis of the full sample provided evidence that a typical respondent would pay premium prices for a bottle of liquid soap that is certified to be eco-friendly, is hypo-allergenic, contains natural ingredients, and has antibacterial properties. However, by dividing the full sample into four latent classes, a typical respondent in one latent class would pay more to avoid the antibacterial component. This study highlights the importance of accounting for preference heterogeneity across respondent subgroupings to better understand preferences and awareness of ingredients in liquid soaps that can pose environmental risk such as antibacterial chemicals. We therefore conclude that this study supports the growing evidence that households generally would not only prefer to use household products for their own personal and health benefits (Veronesi et al., 2014; Wang and Li, 2006), but they would also be willing to pay a premium price for products that have been guaranteed to reduce environmental impacts through product certification or eco-labelling (Cai et al., 2017). Our results also show that all respondents would pay more for liquid soap with natural ingredients that do not harm the environment. In addition, a significant proportion of respondents also would be prepared to pay to avoid liquid soap with antibacterial ingredients or emerging contaminants that have been found harmful to human health and the environment.

Our study has identified both the core (e.g. product certification and presence of antibacterial ingredients) and other factors (e.g. not animal tested and neat to use) that respondents considered in their purchase of liquid soap. These factors should be included in informing or educating consumers about emerging contaminants in consumer products. As we found a preference for liquid soap with no antibacterial ingredients, we recommend that product manufacturers should state the absence of antibacterial ingredients in their product labels. Government agencies, product manufacturers and independent product certification entities should work together to promote the use of liquid soaps and other related household products that are free of these emerging contaminants. The inclusion of emerging contaminant in the eco-labelling system can promote or advocate the exclusion of emerging contaminants from household products.

Given the growing consumer interest in reducing environmental impacts and the increasing number of scientific findings on emerging contaminants, additional information should be supplied on emerging contaminants and related issues on product labels to ensure consumers are better informed. We hope that future studies on household preferences of consumer products will provide further insight on the willingness to pay for products that minimise negative health and environmental impacts.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2019.07.002.

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