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Do Consumers Select Food Products Based on Carbon Dioxide Emissions? Evidence from a Buying Experiment in Japan

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Abstract

This study investigates whether consumers select foods based on the levels of carbon dioxide (CO_2) emissions by using a choice experiment in the laboratory. Respondents are asked to purchase a few Satsuma mandarin oranges based on price and the levels of CO_2 emissions during different stages of their life cycle of production until packing and to answer questions on environmental consciousness, knowledge, and behavior. The following results are obtained: (i) the result for the high and low groups with respect to environmental consciousness is only significant different. (ii) the willingness to pay (WTP) estimate for the reduction of 1g of CO_2 emissions per Satsuma mandarin orange is significantly lower for the low environmentally conscious group than it is for the high environmentally conscious group; (iii) the choice reasons selected by the respondents indicate that the low environmentally conscious group is less likely to select foods based on their CO_2 emissions, whereas the high environmentally conscious group is indifferent to both price and the levels of CO_2 emissions; and (iv) socioeconomic characteristics such as gender, age, and education influence the selection of foods on the basis of CO_2 emissions in the low environmentally conscious group. However, this is not the case in the high environmentally conscious group. Therefore, this study implies that regardless of consumers' environmental knowledge and behavior, the higher their environmental consciousness, the greater their likelihood of selecting foods with lower environmental loads.

Key words: carbon dioxide emissions, choice experiment, consumer preference, food choice, laboratory experiment, random parameter logit

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1. Introduction

A number of labels affixed on foods indicate the nutrition levels of their ingredients in terms of calories. Recently, under the protection of the Kyoto Protocol in 1997, new eco-labels have begun appearing on foods though the eco-label was previously affixed only on non-foods (e.g., cars, household appliances, etc.); this protocol mandates that in 2008–2012, some developed countries must reduce greenhouse gas (GHG) emissions by at least 5% as compared to that in 1990. Since the eco-label on a non-food product indicates that it has the merits of being economical and low running cost, consumers purchasing non-foods attribute importance to whether or not the eco-label is affixed on the product. As a result, some consumers increasingly select those non-foods that possess labels indicating low environmental load. With respect to studies on eco-labeling, empirical analyses (Wessells et al., 1999; Johnston et al., 2001; Teisl et al., 2002; Bjørner et al., 2004; OECD, 2005; Teisl et al., 2008; Brécard et al., 2009)[1], theoretical models (Kirchhoff, 2000; Amacher et al., 2004; Hamilton and Zilberman, 2006; Ibanez and Grolleau, 2008), and experimental methods (Cason and Gangadharan, 2002) have all indicated that eco-labeling has positive effects on the purchasing behavior of the consumer, respectively. Moreover, the environmental factors such as environmental attitudes, knowledge, and behavior are more likely to influence socioeconomic characteristics (Diamantopoulosa et al., 2003).[2]

A new kind of label for foods indicates environmental information in terms of the amount of CO_2 emissions (e.g., carbon footprint[3], carbon offset[4], food miles[5])[6] as well as the biologically productive land and sea area (e.g., ecological footprint[7]). However, these labels do not have the same merits as them for non-foods. Moreover, foods with a lower environmental load do not always taste better as compared to those with a higher environmental load. Therefore, the knowledge of whether consumers attribute higher value to foods with a lower environmental load is important for producers who may introduce their foods with labels and to policy makers who would design an environmental policy. The abovementioned studies may enable producers and policy makers to anticipate whether consumers attribute a higher value to foods with eco-labels. The following studies on food would further enable them to anticipate whether they distinguish between foods with lower and higher environment loads: Roe and Teisl (2007) investigate consumer reactions to labels that have written

[1] Wessells et al. (1999), Johnston et al. (2001), Teisl et al. (2002), and Brécard et al. (2009) used seafood products. Bjørner et al. (2004) used toilet paper, paper towels, and detergents. Teisl et al. (2008) used “greener” vehicles.
[2] Diamantopoulosa et al. documented the following as the components of environmental consciousness: attitudes towards environmental quality, knowledge regarding green issues, and levels of environmentally sensitive behavior. They conducted interviews and surveys by mail in the UK.
[3] For more details on carbon footprint and Carbon Trust, refer to Wiedmann and Minx (2008) and http://www.carbon-label.com/, respectively.
[4] For more details on carbon offset, refer to the Carbon Neutral Company site (http://www.carbonneutral.com/).
[5] For more details on food miles, see Hill (2008).
[6] The amount of CO_2 emissions is calculated by several sites as indicated in Kim and Neff (2009).
[7] For more details on the ecological footprint, see the Global Footprint Network site (http://www.footprintnetwork.org/en/index.php/GFN/).

information on the presence and potential effects of genetically modified (GM) food ingredients and about the agencies that certify these claims by using a mail survey. They indicated that consumers prefer simple GM labels to no GM labels and that although the adequacy of a simple GM label is enhanced if the label comprises the reason for using GM techniques, the addition of this reason in the label significantly erodes the label's credibility ratings. Bernings et al. (2010) investigate shopper preferences for nutritional information provided on grocery store shelf labels by using a choice experiment and concluded that this information influenced consumers since they are more likely to seek healthier items instead of those items without any shelf label information. However, producers and policy makers cannot anticipate whether consumers select foods based on environmental factors such as the levels of CO_2 emissions or on the price and foods characteristics such as appearance and taste. Hence, consumer behavior on food choices must be investigated under the real conditions that they actually purchase foods based on price, environment indicator such as CO_2 emissions, and the appearance of foods and analyzed using environmental factors such as environmental consciousness, knowledge and behavior.

This study investigates whether consumers select Satsuma mandarin oranges (*Citrus unshiu* Marc.), which is the most representative fruit of Japan, by conducting a non-hypothetical choice experiment (CE) in the laboratory. The respondents were provided with the price and information on the levels of CO_2 emissions based on the life cycle inventory of this type of orange, and they were asked to purchase them in 12 rounds. After each round, they selected the reason for their choice from among the following four factors: price, CO_2 emissions, appearance, and others. At the end of the experiment, the respondents were asked to answer three types of questionnaires regarding environmental factors (i.e., environmental consciousness using a psychological scale, environmental knowledge of eco-labels, and environmental behavior, which respondents exhibit in daily life). Finally, the respondents could take the earnings and the oranges that they had selected in each round. Similar to this study, Alfnes et al. (2006) designed an experimental market with posted prices and used the CE for investigating consumers' willingness to pay (WTP) for the color of salmon fillets. They demonstrated that consumers use color as a quality indicator of salmon and are willing to pay significantly more for salmon fillets with normal or above-normal redness than for paler salmon fillets, which implies that color influences consumer preferences.

The CE approach used in this study is a type of stated preference method (Louviere, 2000) such as the contingent valuation method and the conjoint analysis, which is a measure of the consumer's preference elicitation to non-market goods (e.g., environment goods, health risk).[8] Moreover, the CE approach is useful for effectively overcoming certain biases (e.g., strategic bias,

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[8] Although the second-price sealed-bid auction is also a measure of preference elicitation, we used the CE methods in this study because we focused on consumers' choice behaviors in conditions that were as close to the real conditions as possible.

compliance bias, and warm glow bias)[9], which the data in the contingent valuation method usually possesses; this is because the translation of the commodities' features into attributes permits analysts to assess the effect of a change in the objective properties of commodities. Moreover, a hypothetical condition in the CE also possesses a hypothetical bias such that the WTP under this condition is more than that under a real condition (Kurse and Thompson, 2003; Lusk and Schroeder, 2004; Harrison and Rutström, 2008; Chang et al., 2009; Aoki et al., 2010). Therefore, the WTP must be investigated by using the CE under real conditions. Although field studies have the obvious advantage of creating a more natural environment and in increasing a sample, the real condition in this study uses experimental methods with monetary incentives. This is because these methods can clearly indicate the factors that influence consumers' preference for foods providing information regarding CO_2 emissions and why consumers prefer such foods as compared to those that do not provide this information.

The remaining paper is organized in the following manner: Section 2 explains the experimental design and procedure. Section 3 describes the empirical model structure. Section 4 presents the results, and Section 5 indicates the conclusions.

2. Experimental design and procedure

2.1. Design

We conducted a laboratory experiment based on the CE method. As indicated in Appendix A, the three alternatives in the designated choice sets were Satsuma mandarin oranges A, B, and C.[10] Satsuma mandarin oranges[11] were used in this study for the following reasons: First, Satsuma mandarin oranges are the leading fruit in Japan in terms of production and consumption. Therefore, the respondents ought to be familiar with this product. Second, these oranges do not require additional CO_2 emissions because they can be eaten directly without cooking or using any other tools. Third, since the period of the experiment corresponds to that when oranges are in season, it is likely that it is easy for respondents to remember the taste of the oranges even though they do not eat them during the experiment.

The attributes being tested in each round of this study were the price and the CO_2 emission

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[9] For more details on this issue, see Louviere et al. (2000).

[10] In the study, the alternative of "no purchase" does not exist because our purpose is to test whether consumers select foods based on the levels of CO_2 emissions; the frequency of individuals selecting foods on this basis was found to be greater under the real condition (Lusk and Schroeder, 2004).

[11] We used the goku-wase, a type of Satsuma mandarin orange, in this study. Each Satsuma mandarin orange was approximately 7 cm in diameter, and its weight was approximately 100g. We purchased the Satsuma mandarin oranges from three different prefectures (i.e., Wakayama, Ehime, and Kumamoto) and the largest quantities of these oranges are available[11] at supermarkets and stores in these areas. Its color was orange with a bluish tinge. As compared to other types of Satsuma mandarin oranges, the taste of these oranges was sour. The sugar content in them was approximately 9–11 brix. For more details on Satsuma mandarin oranges, see Morton (1987).

levels.[12] The levels of the price attribute were JPY 25, 35, and 45 per Satsuma mandarin orange. These levels were based on the prices of Satsuma mandarin oranges in the three largest supermarkets in the area and on the data obtained from the Statistical Bureau in the Ministry of Internal Affairs and Communications.[13] The levels of the CO_2 emissions attribute were 20g, 30g, and 40g per Satsuma mandarin orange. These levels were based on the life cycle assessment (LCA) because it was found that the amounts of the CO_2 emitted in the LCA process differed for different food products. The LCA in this study comprised the following four stages: production, fruit sorting and box packing, transportation, and packaging.[14] Table 1 shows the CO_2 emissions calculated in each process.[15] Therefore, a full factorial design with three prices and three CO_2 emissions levels would have resulted in 729 alternative management combinations. Since this would constitute an unreasonably large design in practice, a D-optimal fractional factorial design with 24 alternatives was developed and separated into two blocks of 12 choice sets by using Design Expert (version 7).

Table 1 is around here

In order to evaluate the effect of the following environmental factors on consumers' purchase decisions, the questionnaire consisted of three types of questions regarding the environment, as indicated in Appendix B: (i) environmental consciousness (hereafter EC), which is estimated using a psychological scale and indicates the ecologically conscious consumer behavior (Roberts, 1996). In this study, the effect of this factor is estimated on the basis of 10 questions that are designed for assessing the consumers' ecological purchase behaviors by asking respondents to rate the veracity of various statements with respect to their purchase behavior and its connection to environmental product attributes; (ii) environmental knowledge of eco-labels (hereafter EK), the effect of which is estimated by asking respondents to identify 24 eco-labels that aid the purchase of environmentally friendly goods and 11 eco-labels that serve as identifying marks in Japan[16]; and (iii) environmental behavior in daily life (hereafter EB), the effect of which is estimated using six questions that evaluate consumer's behaviors in daily life and otherwise.

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[12] The appearance was used in the choice reasons and not the attributes because it is subjectivized by individuals.

[13] This data indicates the prices of the Satsuma mandarin oranges that were sold at all the supermarkets and shops in Japan. We selected the prices from the available price data for the Osaka prefecture.

[14] In this study, we do not add the levels of CO_2 emissions of oranges during their sale in supermarkets and stores because a number of other goods are present there.

[15] This was referred to by Nemoto (2007).

[16] They are selected from the database of the Ministry of the Environment (http://www.env.go.jp/policy/hozen/green/ecolabel/f01.html).

2.2. Procedure

The following is the detailed procedure of the experiment:

Step 1: One of the experimenters read aloud a consent form at the beginning of the experiment. The consent form stated that the respondents would have to purchase Satsuma mandarin oranges 12 times and that they had the right to withdraw from the experiment at any time if they did not wish to make these purchases.[17]

Step 2: An experimenter explained aloud the experimental procedure to the respondents after the experimental instruction sheets were distributed.[18]

Step 3: At the beginning of the round, the respondents received 120 JPY as endowment in order to purchase one Satsuma mandarin orange from among the three types of oranges that were kept in a box.[19] Subsequently, they were asked to select one of the oranges kept in front of them and to select one of the reasons for their choice.

Step 4: Step 3 was repeated until the 12 rounds were completed.

Step 5: After round 12, the respondents were asked to complete a questionnaire that evaluated their socioeconomic characteristics and the effects that environmental factors such as EC, EK, and EB had on their purchase decisions.

Step 6: The respondents received a show-up fee (500 JPY) and their earnings in each round in cash. The earnings were calculated by subtracting the price of the Satsuma mandarin orange that the respondents purchased from the amount they received for purchasing the oranges (120 JPY). Moreover, the respondents could take home the 12 Satsuma mandarin oranges that they had selected in each round.[20]

3. Model structure

In this study, we use the conditional logit model (CL) as well as the random parameter logit model (RPL) for analyzing the data samples. Both these models are based on the random utility theory, which is central to the concept of choice modeling. The basic assumption underlying the random utility approach to choice modeling is that decision makers are utility maximizers, which implies

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[17] A consent form was provided to every respondent during recruitment. The respondents were asked to read it carefully before participating in the experiment. All the respondents signed the form and none of the respondents dropped out of the experiment.

[18] The instructions for the experiment are provided in Appendix C.

[19] The order of the oranges in the box is based on the CO_2 emissions in each alternative, which correspond with the prefectures producing them as indicated in Table 1.

[20] The respondents take home the oranges selected by them on the basis of the CO_2 emission levels in each round where the CO_2 emission levels of 20g, 30g, and 40g correspond to oranges from Wakayama, Ehime, and Kumamoto, respectively. However, two male respondents did not take the oranges home.

that given a set of alternatives, decision makers select the alternative that maximize their utility. The utility of an alternative for an individual (*U*) cannot be observed; however, it may be assumed to consist of a deterministic (observable) component (*V*) and a random error (unobservable) component (ε). Formally, an individual *q*'s utility of alternative *i* can be expressed as $U_{iq} = V_{iq} + \varepsilon_{iq}$. Hence, the probability that individual *q* selects alternative *i* from a particular set *J*, which comprises *j* alternatives, may be expressed as follows:

$$P_{iq} = P(U_{iq} > U_{jq};\, for\ all\ j(\neq i) \in J) = P(\varepsilon_{jq} < \varepsilon_{iq} + V_{iq} - V_{jq};\, for\ all\ j(\neq i) \in J) \quad (1)$$

In order to transform the random utility model into a choice model, certain assumptions regarding the joint distribution of the vector of random error components are required. If the random error components are assumed to follow the type I extreme value (EV1) distribution and to be independently and identically distributed (IID) across alternatives and cases (or observations), a CL model (McFadden, 1974) can be obtained. Assuming that the deterministic component of utility in the CL model is linear and additive in parameters, $V_{iq} = \beta' \mathrm{X}_{iq}$, the probability in Equation (1) may be expressed as follows:

$$P_{iq}(\beta'_q) = \frac{exp(\mu\beta'\mathrm{X}_{iq})}{\sum_{j=1}^{J} exp(\mu\beta'\mathrm{X}_{jq})}, \quad (2)$$

where μ represents a scale parameter that determines the scale of the utility, which is proportional to the inverse of the distribution of the error components and is typically normalized to 1.0 in the conditional model. X_{iq} denotes the explanatory variables of V_{iq}, typically including alternative-specific constants (ASCs) of the attributes of alternative *i* and socioeconomic characteristics of individual *q*, and β' is the parameter vector associated with matrix X_{iq}.

However, the CL model is also limited in that it assumes all respondents share the same parameters for the attributes, thereby implicitly assuming that there is homogeneity of preferences across all the respondents sampled. Moreover, the CL model assumes the independence of irrelevant alternatives (IIA) property.[21] If the IIA property is violated, the results of the CL model will be biased. This implies that a discrete choice model that does not require the IIA property, such as the RPL model (Train, 1998, 2003), must be employed. In contrast with the CL model, since the coefficients in the RPL model vary among respondents, the utility that an individual *q* derives from selecting alternative *i* on choice set *t* may be expressed as $U_{iqt} = V_{iqt} + \varepsilon_{iqt} = \beta'_q X_{iqt} + \varepsilon_{iqt}$. The density for β'_q is denoted as $f(\beta | \theta)$, where θ is a vector of the true parameters of the taste distribution. The conditional probability of alternative *i* for individual *q* in choice set *t* is expressed as follows:

[21] The IIA property states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives.

$$P_{iqt}(\beta'_q) = \frac{exp(\beta'_q X_{iqt})}{\sum_{j=1}^{J} exp(\beta'_q X_{jqt})}, \quad (3)$$

The probability of the observed sequence of choices conditional on knowing β'_q is expressed as follows:

$$S_q(\beta'_q) = \prod_{t=1}^{T} P_{qi(q,t)t}(\beta'_q), \quad (4)$$

where *i (q, t)* represents the alternative selected by individual *q* on choice set *t*. The unconditional probability of the observed sequence of choices for individual *q* is the integral of the conditional probability in Equation (4) over all possible variables of β' and can be expressed as follows:

$$P_q(\theta) = \int S_q(\beta) f(\beta \mid \theta) d\beta. \quad (5)$$

In most applications, the density $f(\beta \mid \theta)$ has been specified to be normal or lognormal: $\beta \sim N(b, W)$ or $\ln \beta \sim N(b, W)$ with mean, *b*, and covariance, *W*, are estimated.[22] In this study, we use normal density.

Based on the above discussions, the main effect in Model 1 is estimated using the CL and the RPL models because of the result obtained in the Housman test.[23] Further, the main effect in Model 2 is estimated using the RPL model for the analysis with socioeconomic characteristics in two indirect utility functions as below.

Model 1: $V_{iq} = \beta_1 PRICE_i + \beta_2 CDE_i$,

Model 2: $V_{iq} = \beta_1 PRICE_i + \beta_2 CDE_i + \sum_{k=1}^{K} \delta_k CDE_i \times SOCIO_{kq}$,

where $PRICE_i$ is the price level of Satsuma mandarin orange *i*, CDE_i is the CO_2 emission level of Satsuma mandarin orange *i*, and $CDE_i \times SOCIO_{kq}$ is the interaction term of the CO_2 emission level of Satsuma mandarin orange *i* with a dummy variable indicating the socioeconomic characteristics *k* of individual *q*. β_1, β_2, and δ_k are parameters that are to be estimated.

4. Results

We conducted the laboratory experiment at the Osaka University. The respondents were recruited from the Osaka University campus and from among the neighborhood residents from a randomly selected sample of 5,700 households around the university. We recruited student and non-student

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[22] There are other densities specified as triangular, uniform, and Rayleigh distributions. See Train (2003) (pp.142) and Hensher and Greene (2003).

[23] In this study, the Hausman test for the independence of irrelevant alternatives (IIA) property (Hausman and McFadden, 1984) provided that the IIA property cannot be rejected only in the case where alternative C is dropped (chi-square (2) = 430.842, p-value = 0.000) (The following are the other results: if alternative A is dropped (chi-square (2) = 0.570, p-value = 0.752), and if alternative B is dropped (chi-square (2) = 2.597, p-value = 0.273)).

subjects in order to include members from different socio-economic backgrounds rather than only student subjects. Student subjects were recruited by leaflets on-campus advertisements. Non-student subjects were recruited by advertising the survey through leaflets inserted in four kinds of Japanese newspapers.[24] We conducted 15 sessions with 104 respondents (63 residents and 41 students) during November 4–9, 2008.[25] Each respondent was permitted to participate in only one experimental session. On an average, each respondent earned 1,407 JPY. Each session lasted for approximately 60 minutes.

Here, in order to investigate which environmental factors consumers are influenced when they select the oranges based on the levels of CO_2 emissions, we will employ the results of the three environmental factors, i.e., EC, EK, and EB, used in the questionnaire. First, the Spearman rank correlation coefficients between EC and EK and those between EC and EB were 0.147 (p-value = 0.000) and 0.282 (p-value = 0.000), respectively. Second, the raw data for each environmental factor was divided into the following two groups: the high group, which consisted of respondents whose responses were more than the average synthesis scales in EC and the average number in EK and EB, and the low group, which consisted of the other respondents in each factor.[26] The results of the LR test only indicate significant differences between the high and low groups for the EC factor (chi-square(2) = -2(-1107.579 -(-545.375-550.912)) = 22.585, p = 0.000)) at the 5% significant level.[27]. Therefore, since EC bears a more significant influence on consumers' selection of oranges based on the CO_2 emissions, the results will be analyzed for these two groups only for the EC factor.

Table 2 shows the results of Model 1, which employs the CL and the RPL models, and Model 2, which employs the RPL model with interactions, for the high and low environmentally conscious groups by using LIMDEP 9.0 NLOGIT 4.0. Here, we use a simulated maximum likelihood estimator in order to estimate the models by employing Halton draws with 100 replications (Revelt and Train, 1998; Train, 2000). The variable *CDE* is specified to be normally distributed (Revelt and Train, 1998; Train, 1998; Carlsson et al., 2003). The estimates of the two variables, *Price* and *CDE*, indicated significant and negative signs for both the groups, implying that all the respondents preferred to purchase Satsuma mandarin oranges that were cheaper[28] and emitted

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[24] The newspapers are Mainichi, Asahi, Yomiuri, and Sankei which are major ones in Japan.

[25] The socioeconomic characteristics of the respondents in the experiment are summarized in Appendix D.

[26] In the EC, a synthesis scale aggregates the scales of all the questions. This scale's Cronbach's alpha reliability coefficient is 0.839. Therefore, the two groups under EC are defined as the high group, which consists of respondents whose responses are more than the average synthesis scale of 30, and the low group, which comprises the other respondents. In the EK, the high group includes respondents whose responses are more than the average number of 11. In the EB, the high group includes respondents whose responses are more than the average number of three; question 7 is excluded.

[27] In CL model also, the results were the same as that of the RPL model (chi-square (2) = -2(-1111.141 - (-547.243 - 552.238)) = 23.320, p = 0.000). The results of the LR test indicate insignificant for the EK (chi-square(2) = -2(-1107.579-(-553.503-551.755)) = 4.642, p = 0.098) and the EB factors (chi-square(2) = -2(-1107.579 -(-638.925 -466.853)) = 3.602, p = 0.165), respectively.

[28] The result of cheaper purchases supports Prescott et al. (2002), which indicated that Japanese consumers particularly ascribed value to price.

lower levels of CO_2 regardless of the degree of EC. However, the marginal WTP estimate for the reduction of 1g of CO_2 emission per Satsuma mandarin orange in the low environmentally conscious group was lesser than that in the high environmentally conscious group. This implies that the higher the environmental consciousness, the more people may value foods that emit lesser CO_2.

Subsequently, with respect to Model 2, which uses the RPL model with interactions, none of the variables except the attributes in the high environmentally conscious group are significant. However, in the low environmentally conscious group, the three variables *CDE × Female, CDE× Old, and CDE× University* were estimated to have significant, negative, and positive signs, respectively. This implies that female respondents attribute greater value to CO_2 emissions as compared to male respondents, which supports the findings in Wessells et al. (1999), Diamantopoulosa et al. (2003), Teisl et al. (2008), and Brécard et al. (2009).[29] Further, it implies that younger respondents attribute greater value to CO_2 emissions as compared to older respondents, which does not support the findings in Moon et al. (2002),[30] and that high school educated respondents attribute greater value to CO_2 emissions as compared to university educated respondents, which support the finding in Johnston et al. (2001) but not that in Teisl et al. (2008)[31]. Therefore, although the preferences of the high group are more likely to be the same regardless of socioeconomics characteristics, those of the low group may differ.

Here, the results of the two environmentally conscious groups, as indicated above, may also indicate the results of the choice reasons in each choice set. Table 3 shows the average number of times a particular choice reason has been selected and the results of the Freidman test for the two environmentally conscious groups. Similar to the results of the LR test, the Mann-Whitney U tests indicated significant differences between the reasons provided by the high and the low groups with respect to the choice reasons at the 1% significance level.[32] Since the Friedman rank sum test initially indicates significant differences between the choice reasons in both high (chi-squared = 13.192, p = 0.001) and low groups (chi-square = 35.106, p = 0.000), we will analyze which reasons there are significant different. The Friedman test indicates that there is a significant difference between "Appearance" and other reasons in the low group and between "CDE" and other reasons in the high group.[33] These results imply that the respondents in the low group ascribed lesser value to CO_2 emissions as compared to price and appearance, and that the respondents in the high group

[29] They found that females tend to possess and exhibit better knowledge and behavior regarding green issues than males.
[30] They found that older individuals consider environmental information more credible.
[31] Although Johnston et al. (2001) found that more educated individuals do not necessarily ascribe greater importance to environmental information, Teisl et al's (2008) results were contrary to this finding.
[32] The results of the Freidman test show in the choice reasons "Appearance" (z-statistics = -4.392, p = 0.000), "Price" (z-statistics = 20.665, p = 0.000), and "CDE" (z-statistics = -17.807, p = 0.000), respectively.
[33] Similar to other multiple comparison tests, Tukye's test for the comparison of the mean values also indicates significant differences between the choice reasons in the high group (Appearance vs. Price (t = 6.995, p = 0.000) and Appearance vs. CDE (t = 7.286, p = 0.000)) and the low group (Appearance vs. CDE (chi-square = 10.362, p = 0.000) and Price vs. CDE (chi-square = 9.965, p = 0.000)).

ascribed greater value to appearance and are indifferent to price and CO_2 emissions. Hence, the differences between the high and low groups in the EC category will influence the food choice behavior when consumers select foods based on their levels of CO_2 emissions.

Tables 2 and 3 are around here

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5. Conclusions

This study investigates whether consumers ascribe greater importance to CO_2 emission levels over the prices and appearances of oranges while purchasing them. The results indicate that respondents with low environmental consciousness ascribe lesser value to selecting oranges based on their CO_2 emission levels and that the socioeconomic characteristics of such respondents differ from those with high environmental consciousness who are indifferent to the price and CO_2 emission levels of oranges. However, it was found that respondents ascribe value to appearance regardless of the degree of their EC, which finding supports that of Bougherara and Combris (2009) who indicated that consumers ascribe greater importance to food characteristics such as taste or appearance as compared to environmental protection.[34] Hence, these results in our study imply that the increasing the level of environmental consciousness may enable consumers to select foods with low environmental load.

The introduction of attaching new labels to foods as well as non-foods across the world has facilitated the process of including everyday commodities for increasing environmental consciousness. This is rather advantageous for reducing the amount of CO_2 emissions in consumer-oriented sectors such as the residential sector as well as the commercial sectors. However, producers and policy makers must consider the following two points for increasing consumer's environmental consciousness for foods with the help of these new labels. First is the different degrees of environmental consciousnesses of individuals as indicated in this study. There is an example as the change environmental consciousnesses of individuals over time: Grankvist and Biel (2007) investigated consumers' foods choice behaviors for identifying the importance ascribed to environmental consequences by conducting a mail survey over a period of 18 months and found that the relative purchase frequency of consumers who had initially reported that they had never

[34] Bougherara and Combris (2009) employed the Becker–DeGroot–Marschak (BDM) procedure involving real transactions for investigating whether the premium consumers who are willing to pay for eco-labeled orange juice are driven by selfish or altruistic motives. This study specified that the eco-label on the product indicated that the product is organic and that the agricultural technique contributes to environmental protection. Moreover, the subjects who purchased the orange juice could take it home. They found that consumers' willingness to pay for the eco-labeled orange juice does not result from a perception of better taste or higher safety attributes, but from the desire to contribute to public good for purely altruistic reasons, or selfish motives other than food taste or safety.

purchased eco-labeled foods subsequently increased according to environmental consequences and that they had purchased them before, however, started to purchase based on eco-labelled product characteristics such as taste and price. Second is the difference among geographical conditions such as the area and climate of different countries, which has not been studied here. For example, the degree of self-sufficiency of a country influences the residents' food purchases. Since the degree of self-sufficiency in Japan is low, consumers always find foreign foods in supermarkets and shops. Foreign foods emit higher amounts of CO_2 but are cheaper than domestic foods. As a result, a few consumers purchase them owing to its lower price and regardless of its influence on the environment. Since consumers' food choice behaviors also depend on the country characteristics, producers and the policy makers in the countries with low degrees of self-sufficiency must prudently employ the same methods that are successful in countries with a high degree of self-sufficiency.

This study suggests two possible directions for further research. First, since the sensory information obtained from the process of eating a food product influences consumer behavior more than other types of information (Prescott and Young, 2002; Aoki et al., 2010), it is essential to compare the taste and/or nutrition of a food product with the consumer's environmental consciousness. Second, in order to increase the validity of the estimates, the WTP must be compared with those obtained by the other methods because the data in the CE possesses a starting point bias (Ladenburg and Olsen, 2008). However, the existence of this bias is not supported in all the studies; Ohler et al. (2000) and Hanley et al. (2005) found the starting point bias even though the price vector changed, whereas the findings of Carlsson and Martinsson (2007) and Ryan and Wordsworth (2000) indicated the opposite.

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Table 1. The CO_2 emissions based on life cycle inventory

Prefecture	Total CO_2 emissions (g/ a Satsuma mandarin orange)	Products[a]	Fruit sorting and box Packing[b]	Transportation[c]	Packaging[d]
Wakayama	23.192	16.295		1.587	
Ehime	32.268	20.391	0.402	6.570	4.716
Kumamoto	34.304	16.591		12.402	

Note: [a] quotes from the data in National Institute of Agro-Environmental Sciences (see:)(i.e., 360–370 g-CO_2/10 a) and Ministry of Agriculture, Forestry and Fisheries (see: In our study, the CO_2 emissions level is approximately 365 g-CO_2/10 a and the annual yield in Satsuma mandarin oranges in Wakayama, Ehime, and Kumamoto are, 2,240,000, 1,790,000; and 2,260,000 g per 10 a, respectively. We calculate the CO_2 emissions per a Satsuma mandarin orange.

[b] quotes from data in Nemoto (2007).

[c] is based on data obtained from the Ministry of Land, Infrastructure and Transport. We calculate the CO_2 emissions from each prefecture from where the oranges are obtained to the supermarket in the area via Osaka prefecture central wholesale market by track. A lot of food products are collected in this market and sent to supermarkets and stores. The running distance is calculated using a searching route by car on the Nippon Oil Corporation site

[d] is based on the Ajinomoto Group LC-CO_2 emissions factor database for food related materials (1990, 1995, and 2000 editions; 3 EID compliant (Ajinomoto Co., Inc.). We calculate the CO_2 emissions when 12 pieces of goku-wase Satsuma mandarin oranges are packed in a plastic bag and sealed with tape. The plastic bag is made from polyethylene (PE) and weighs an average of 4.1 g. In the Ajinomoto Group LC-CO_2 emissions factor database for food related materials (1990, 1995, and 2000 editions; 3 EID compliant (Ajinomoto Co., Inc.), the CO_2 emissions in goods made from PE is 10.302 g-CO_2/g. A tape made of polyethylene terephthalate (PET) weighs 0.1 g on average. In the Ajinomoto Group LC-CO_2 emissions factor database, the CO_2 emissions in goods made from PET (excluding fabric goods) is 2.333 g-CO_2/g.

Table 2. The conditional logit and the random parameter logit regression results in main effects for high and low environmentally conscious groups

Variables	Conditional logit		Random parameter logit				Random parameter logit with interactions			
	High	Low	High		Low		High		Low	
	Coefficient	Coefficient	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation
Price	-0.0974*** (0.008)	-0.1190*** (0.008)	-0.1054*** (0.010)	-	-0.1309*** (0.012)	-	-0.1052*** (0.101)	-	-0.1303*** (0.011)	-
CDE	-0.0774*** (0.008)	-0.0404*** (0.007)	-0.0897*** (0.012)	0.0782*** (0.029)	-0.0446*** (0.009)	0.0810** (0.033)	-0.0610** (0.030)	0.0724** (0.030)	-0.1029*** (0.037)	0.0580* (0.034)
CDE × Female							-0.0028 (0.030)	-	-0.0560*** (0.019)	-
CDE × Old							-0.0125 (0.033)	-	0.0362* (0.020)	-
CDE × High Income							-0.0234 (0.021)	-	0.0022 (0.017)	-
CDE × University							-0.0028 (0.023)	-	0.0795** (0.035)	-
Marginal willingness to pay (JPY)	0.795	0.339	0.851		0.341		-		-	
Log likelihood	-547.243	-552.238	-545.375		-550.912		-543.750		-543.946	
McFadden's R^2	0.183	0.208	0.189		0.212		0.191		0.222	
Observations	612	636	612		636		612		636	

Notes: Standard errors are in parentheses. ***, **, and * denote that the parameters are different from zero at the 1%, 5%, 10% significance levels, respectively.

Table 3. Average number of times that particular choice reasons are selected and the Friedman test results of the choice reasons for high and low environmentally conscious groups

	High group			Low group		
Choice reason	Appearance	Price	CDE	Appearance	Price	CDE
Average number of selection per reason	5.673 (3.044)	2.885 (2.758)	2.769 (2.813)	5.250 (3.101)	5.096 (3.331)	1.231 (1.660)
Friedman test						
Comparison	Appearance -Price	Appearance -CDE	Price -CDE	Appearance -Price	Appearance -CDE	Price -CDE
Chi-square (2)	8.715***	10.946***	0.127	0.251	28.766***	23.641***
N	51			53		

Notes: Standard deviations are in parentheses. *** denotes that the parameters are different from zero at the 1% significance level.

Appendix

This supplementary material has four sections. Appendix A provides an example of choice sets. Appendix B provides three kinds of questions on environment as EC, EK and EB. Appendix C shows instructions in the experiment. Appendix D provides variables and socioeconomic characteristics.

Appendix A: An example of choice sets

	Satsuma mandarin orange A	Satsuma mandarin orange B	Satsuma mandarin orange C
Price (JPY)			
Carbon dioxide emissions (grams)			
I would choose…	□	□	□
The most important reason affecting my choice	□Price □Carbon dioxide emissions □Appearance □Others[the reason:]		

Appendix B: questionnaire on environment

1. 10 ecologically conscious consumer behavior questions in environmental consciousness (EC)

No.	Syntax (cronbach's alpha = 0.839)	Average ECCB scale [a]		
		Total	High	Low
E1	I have purchased a household appliance because it uses less electricity than other brands.	3.436 (1.085)	3.920 (0.882)	2.962 (1.056)
E2	I have purchased light bulbs that are more expensive but that save energy.	2.767 (1.225)	3.432 (1.071)	2.115 (0.994)
E3	I will not buy products that have excessive packaging.	2.951 (1.152)	3.490 (0.916)	2.423 (1.116)
E4	If I understand the potential damage to the environment that some products can cause, I do not purchase these products.	3.602 (0.949)	4.020 (0.671)	3.192 (1.001)
E5	I have switched products for ecological reasons.	2.932 (0.927)	3.451 (0.848)	2.423 (0.689)
E6	I have convinced members of my family or friends not to buy some products that are harmful to the environment.	1.980 (0.924)	2.528 (0.893)	1.442 (0.569)
E7	Whenever possible, I buy products packaged in reusable containers.	3.078 (0.952)	3.588 (0.845)	2.577 (0.768)
E8	When I have a choice between two equal products, I always purchase the one that is less harmful to other people and the environment.	3.544 (1.069)	4.059 (0.850)	3.038 (1.019)
E9	I will not buy a product if the company that sells it is ecologically irresponsible.	3.165 (1.081)	3.822 (0.858)	2.519 (0.866)
E10	I do not buy household products that harm the environment.	2.961 (1.157)	3.647 (0.925)	2.288 (0.948)

Notes: Standard deviations are in parentheses.

[a] Scoring scale: always true = 5, mostly true = 4, sometimes true = 3, rarely true = 2, and never true = 1. Higher numbers mean a higher probability of engaging in the particular behavior.

2. The 35 eco-labels under the Environmental Knowledge (EK) category:

How many Eco-labels do you know? (Multiple choices permitted)

3. Seven questions of daily life under the Environmental Behavior (EB) category:

To what extent do you act in an environmentally friendly manner? (Multiple choices permitted)

	Mean	Std. Dev.
1. I have not used any shopping bags for purchasing anything.	0.660	0.474
2. I often use public transportation or a bicycle, but not a car.	0.505	0.500
3. I do not leave the tap running and often turn off a light when not in use.	0.893	0.309
4. I adjust the room temperature in accordance with health.	0.786	0.410
5. I always use the stairs and not elevators and escalators.	0.252	0.434
6. I separate the garbage.	0.864	0.343
7. Others	0.136	0.343

Appendix C: Instruction in the experiment (original text in Japanese)

You are participating in an experiment that is designed to study decision making. In this experiment, you will be asked to buy one of three types of Satsuma mandarin oranges, which we will provide. Please read and follow the instructions carefully. In addition, you cannot communicate with others during the experiment or take any remaining Satsuma mandarin oranges with you after the experiment is completed without instructions regarding the same.

Overview

This experiment consists of 12 rounds. In each round, you must choose one of three types of Satsuma mandarin oranges, which we will provide, and pay for it with the money given to you.

This particular type of Satsuma mandarin orange is goku-wase. It is cultivated in gardens in Japan and you must have seen it in stores. The experimenters have bought them at Japan Agriculture and some other food stores. At the end of the experiment, the proof of purchase will be shown by the experimenters.

You will receive your earnings in cash, based on the formula below:

Earnings = 12 * {initial income in each round (120 JPY) – the price of the Satsuma mandarin oranges chosen in each round}+ show-up fees (500 JPY)

Moreover, you can take home the 12 pieces of Satsuma mandarin orange which you choose during the experiment.

Rules

At the beginning of round 1, you will receive a hypothetical sum of 120 JPY to buy a Satsuma mandarin orange. You will not actually receive that amount in cash in each round. Please imagine that you have 120 JPY in each round when you make your choice.

Next, you will receive a box containing three types of Satsuma mandarin oranges and a record sheet. Verify your seat number and the round number that appear on it.

We will now consider an example of a "record sheet." This is a record sheet for seat number 1 in round 1. Further, we will explain how to read and fill in the record sheet. The top line, which states "record sheet" and "round 1," indicates the round number and the first seat, which is located on the left hand side of the room.

The second line indicates three alternatives —Satsuma mandarin orange A, Satsuma mandarin orange B, and Satsuma mandarin orange C.

The third line indicates the price levels of the Satsuma mandarin oranges in JPY per 100 g. The price of Satsuma mandarin oranges in each round of the experiment is less than the money you receive to buy it (i.e., 120 JPY).

The fourth line indicates the CO_2 emission levels of the three Satsuma mandarin oranges in grams per 100 grams of Satsuma mandarin orange. These figures indicate the CO_2 emission levels that are produced during the following processes: production, fruit sorting and box packing, transportation and packaging. The CO_2 emissions contribute to global warming. The amount of the CO_2 emissions is based on data obtained from the Ministry of Land, Infrastructure, and Transport, The National Institute for Agro-Environmental Science and the Ajinomoto Group in Japan.

The Satsuma mandarin oranges that you are going to choose are of the goku-wase variety, which grow in gardens. The distance between the place of harvest and the store selling the oranges affects the amount of CO_2 that is emitted. For example, the closer the proximity of the selling location is to the place of harvest, the lower the amount of CO_2 emissions is and vice versa.

The fifth line provides space for you to indicate your decision. Please tick in the square that corresponds to the Satsuma mandarin orange of your choice. So, if you choose Satsuma mandarin orange A, please indicate the same in the corresponding square.

The last line provides the column for you to indicate the reason for your choice. The reasons for the choice consist of four factors: price, the CO_2 emissions, the appearance of the Satsuma mandarin orange, and others. Please tick inside the square that corresponds to the reason why you have selected the particular Satsuma mandarin orange. For example, if you choose price as the reason, you should tick the square in the price column. Finally, close the box and wait for the experimenter to collect it.

The experimenter will collect all of the boxes in the room. This completes round one. The rules in round 2 are exactly the same as those in round 1. Initially, you receive 120 JPY, and then, you receive a box containing three types of Satsuma mandarin oranges and a record sheet. You purchase one of the three types of Satsuma mandarin oranges. After the completion of round 2, round 3 begins. This experiment is repeated a total of twelve times following the same rules. The completion of round 12 signals the end of the experiment.

Earnings

Earnings are calculated as the amount equal to the sum of the participation fee and total of the remaining amounts in twelve rounds. The participation fee is 500 JPY. Since this amount is a reward for your participation, it is not affected by your choices in each round.

Next, we explain the remaining amounts in the six rounds. At the beginning of each round, you receive 120 JPY to buy one Satsuma mandarin orange. The remaining amount in each round is equal to the difference between 120 JPY and the price of the Satsuma mandarin orange you choose. This amount constitutes your earnings in each round. Since this experiment consists of six rounds, you receive the sum of the remaining amount for six rounds. The formula for your earnings in the experiment is provided below.

Earnings = 500 JPY (show-up fee)
+ {(120 JPY – the price of the Satsuma mandarin orange that you buy in round 1)
+ (120 JPY – the price of the Satsuma mandarin orange that you buy in round 2)
+...+ (120 JPY – the price of the Satsuma mandarin orange that you buy in round 12)}

You need not be conscious of others because we never offer your earnings to others. This concludes the explanation of the experiment. Please understand the rules of the experiment and select the Satsuma mandarin orange that you wish to purchase.

Are there any questions before we begin?

Appendix D: Socioeconomic characteristics

Variable name	Definition	Means (Std)
Attributes		
Price	Price of Satsuma mandarin oranges:25, 35, and 45 JPY per orange	35
CDE	The amount of carbon dioxide emissions: 20, 30, and 40 gram per orange	30
Independent variable		
CDE × Female	An interaction term of CO_2 with a dummy variable that is equal to 1 if the respondent is female.	-
CDE × Old	An interaction term of CO_2 with a dummy variable that is equal to 1 if the respondent's age is over 30 years.	-
CDE × High Income	An interaction term of CO_2 with a dummy variable that is equal to 1 if the respondent's income is over 5,500,000 JPY	-
CDE × University	An interaction term of CO_2 with a dummy variable that is equal to 1 if the respondent holds a university or a higher degree	-
Socioeconomic characteristics		
Female	Dummy variable = 1 if the respondent is female	0.654 (0.476)
Age	Categorical variable (1−6): 1 = below 20, 2 = 20−24, 3 = 25−29, 4 = 30−34, 5 = 35−39, 6 = over 40.	4.125 (1.849)
Income (JPY)[a]	Categorical variable (1−5): 1 = below 2,500,000, 2 = 2,500,000−3,999,999, 3=4,000,000−5,499,999, 4 = 5,500,000−6,999,999, 5 = above 7,000,000.	3.851 (2.060)
Education	Categorical variable (1−4): 1 = high school; 2 = college; 3 = university;4 = graduate school of university	2.931 (0.704)

Notes: [a] implies that the experiment indicates annual disposable income other than room rental expenses (JPY).