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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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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 how consumers value carbon dioxide (CO_2) emissions of food by conducting a choice experiment before an ecolabel is attached on some foods in Japan. Participants are asked to buy some Satsuma mandarin oranges based on price and CO_2 emissions and take them home. The following results are obtained: (i) the willingness-to-pay (WTP) estimate for the reduction of 1 g CO_2 emissions per 100 g of Satsuma mandarin oranges is 0.417 JPY; (ii) people below 30 years, who are significantly conscious about the environment, do not choose Satsuma mandarin oranges based on CO_2 emissions and have less value for this; and (iii) people above 30 years, who are environmentally friendly, choose the oranges based on price and have more value for this, although this implies that they do not relate food to CO_2 emissions. Thus, since whether or not people select food based on CO_2 emissions differs across ages, each age group has a different approach to reducing the CO_2 emissions of food.

JEL classification: C91; Q18; Q54

Key words: carbon dioxide emissions, choice experiment, consumer preference, ecolabeling, food labeling, fruit

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1. Introduction

In Japan, some food companies began selling food products bearing a carbon footprint (hereafter CFP) from the spring of 2009 after the government recommended an operation named "MIERU-KA," the visualization of which may encourage consumers to act toward reducing CO_2 emissions when they buy food products. The CFP was attached to certain food products in 2007 by an independent company in England, "The Carbon Trust.[1]" Food was related to the environment in order to increase the environmental consciousness of consumers since the current CO_2 emissions attributable to them were above the 1990 levels.[2]

There exist few studies on the preference elicitation for CO_2 emissions with respect to the use of food. With respect to studies for eco-label by using them, they found that consumers preferred food products with ecolabels to those without ecolabels (Johnston et al., 2001; Loureiro and Lotad, 2005; Grankvist and Biel, 2007).[3] With respect to the preference elicitation for CO_2 emissions, there are a few studies on carbon offsets. Brouwer et al. (2008) investigated whether airline passengers as polluters were supportive of the measures that increased the cost of their travel and compensated for the damage caused by their flights, and quantified the benefits obtained by mitigating their emissions by using the contingent valuation method (CVM) in the airport, indicating that (1) passengers are willing to pay (WTP) 60 Euros per 100 km that they fly on average and (2) this corresponds with the average WTP of about 25 Euros per tonne tCO_2-eq. Akter et al. (2009) investigated airline passengers' preferences regarding a potential carbon travel tax by using the CVM in the airport, indicating that the mean open-ended WTP was between 3 and 4 Euros per 100 km of air travel and 47 Euros per tonne CO_2-eq. MacKerron et al. (2009) investigated the WTP for voluntary carbon offsets in the context of fair travel for leisure, since this is a major market for individual offsets consumption, by using the CVM and a choice experiment (CE) in the online survey. The results suggested that the WTP for the offsets in the CVM was approximately £24 and that the WTP in the CE was approximately £13.

The CVM is the most frequently used method to elicit the WTP for environmental goods. However, the data in the CVM usually has some biases, for example, strategic bias, compliance bias, and warm glow bias.[4] The CE approach is useful to overcome these biases to a great extent because through the translation of commodities' features into attributes, it allows analysts to assess the impact of a change in the objective properties of commodities. Moreover, a hypothetical condition

[1] For more details on the carbon footprint, refer to Wiedmann and Minx (2008), and on the Carbon Trust, refer to the site: http://www.carbon-label.com/.

[2] In Japan, the proportion of CO_2 in the civilian population increased by 36.7% as compared to the 1990 levels (Ministry of the Environment of Japan, 2008). On the other hand, the CO_2 emissions attributable to households were 15% above the 1990 levels in 2004 in the UK.

[3] With respect to the studies by experiment, see Grankvist et al. (2004). The results show that subjects selected goods with ecolabels regardless of whether or not the goods were food.

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

has a hypothetical bias such that the WTP under it is more than that under a real condition (Kurse and Thompson, 2003; Lusk and Schroeder, 2004; Harrison and Rutström, 2008; Hudson et al., forthcoming; Aoki et al., 2008; etc.). Therefore, the WTP needs to be investigated by using the CE under the real condition.

In the present study, we report the WTP of CO_2 emissions levels for the consumers of Satsuma mandarin oranges (*Citrus unshiu* Marc.) by conducting a CE under the real condition such that participants bought the oranges actually. The respondents were provided with the price and the amount of CO_2 emissions based on the life cycle of the oranges and were asked to purchase them in 12 rounds. Next, they selected the reason for their choice from among four factors: price, CO_2 emissions, appearance, and others. At the end of the experiment, the participants were asked to answer some questions related to ecologically conscious consumer behavior (hereafter referred to as ECCB) (Roberts, 1996) and to socioeconomics characteristics. After the experiment, the participants took the earnings and the oranges that they choose in each round.

The design in this paper is similar to that in Alfnes et al. (2006) and Aoki et al. (2008) with respect to using the CE involving the purchase of food. Alfnes et al. (2006) designed an experimental market with posted prices to investigate consumers' WTP for the color of salmon fillets through a CE with real economic incentives. The results show that consumers use color as a quality indicator and are willing to pay significantly more for salmon fillets with normal or above-normal redness than for paler salmon fillets. This implies that color affects choice. Aoki et al. (2008) designed an experimental market with posted prices to investigate consumers' WTP for ham sandwiches with/without food additives through the CE under the real and hypothetical conditions in order to research the effect of information. Here, respondents chose from real products. The results show that consumers prefer a ham sandwich without food additives. The WTP values for a ham sandwich without sodium nitrite are estimated to be lower in the experiment and higher in the survey after a set of negative and positive information is provided, implying that the effect of information provision differs between these two environments.

The real price per tonne of CO_2 emissions posted in the emissions trading market in the European Union GHGs Emission Trading Scheme (EU ETS) was €20.31[5] (3026 JPY[6]) on average (ranging from €12.25 to €32.25) from 2005 to 2007 (European Climate Exchange). Nevertheless, investigating the WTP for CO_2 emissions for users (including consumers) as in the previous studies can help policy makers to design effective financial instruments aimed at discouraging climate-unfriendly activities as well as to generate funds for the measures directed at climate change mitigation and adaptation.

[5] This figure is used as "Dec-08" in the excel data "Prices and Volume: ECX EUA Futures Contract" in European Climate Exchange. For more details on the market for trading CO_2 emissions in EU ETS, see "State and Trends of the Carbon Market Report" in the World Bank (http://www.worldbank.org/).

[6] €1 = 149 JPY on average during 2005–2007. This is calculated using the Foreign Exchange Rate (monthly) declared by the Bank of Japan (http://www.boj.or.jp/en/theme/research/stat/market/forex/fx/index.htm).

The remaining paper is organized as follows. Section 2 explains the designs of the experiment. Section 3 describes the empirical model structure. Section 4 presents the results, and Section 5 proffers the conclusions.

2. Experimental design

2-1. Procedure

We conducted a laboratory experiment based on the CE method. The design of the laboratory experiment was as follows. As shown in Appendix A, the three alternatives in the designated choice sets were Satsuma mandarin orange A, Satsuma mandarin orange B, and Satsuma mandarin orange C. The attributes being tested were price and CO_2 emission levels in each round of this study. Each price attribute was at the following levels: 25 JPY, 35 JPY, and 45 JPY. The CO_2 attribute was at the levels of 20 g, 30 g, and 40 g per 100 g of Satsuma mandarin oranges. The total number of rounds in one session was 12. The detailed procedure of the experiment is as follows.

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 buy Satsuma mandarin oranges 12 times and that they had the right to drop out of the experiment at any time if they did not wish to make these purchases.[7]

Step 2 An experimenter explained the experimental procedure to the respondents after the experimental instruction sheets were distributed.[8]

Step 3 At the beginning of round 1, the respondents hypothetically received 120 JPY to buy a Satsuma mandarin orange and the three types were delivered in a box. Next, they were asked to choose one of the oranges kept in front of them and to explain the reason for their choice. The respondents were informed that an amount equal to the price of the selected Satsuma mandarin orange would be deducted from the 120 JPY that they had hypothetically received.

Step 4 Step 3 was repeated until 12 rounds (i.e., rounds 2 to 12) were completed.

Step 5 After round 12, the respondents were asked to complete a questionnaire to evaluate their environmental consciousness and socioeconomic characteristics.

Step 6 The respondents received their earnings in cash. The earnings were calculated as the amount received to buy the Satsuma mandarin orange (120 JPY) minus the price of the orange

[7] 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 no one dropped out of the experiment.

[8] The experimental instructions are provided in Appendix B.

selected (i.e., 25 JPY, 35 JPY, or 45 JPY) in each round. Moreover, the respondents took home the 12 Satsuma mandarin oranges that they chose in each round.[9]

2-2. Products

We used Satsuma mandarin oranges[10] for the following reasons. First, along with apples, it is Japan's leading fruit in terms of production and consumption. Therefore, the respondents ought to be familiar with these products. Second, unlike vegetables and other fruits, the Satsuma mandarin orange is eaten directly without cooking or using any other tools. Most vegetables require the use of fire and kitchen utensils (e.g., a knife) when they have to be consumed, which influences the amount of CO_2 emissions.

Each Satsuma mandarin orange was approximately 7 cm in diameter, and its weight was approximately 100 g. We bought the Satsuma mandarin oranges from three different prefectures (i.e., Wakayama, Ehime, and Kumamoto) where the largest quantity is available[11] at supermarkets and stores in the area.

The price attribute had levels of 25 JPY, 35 JPY, and 45 JPY per 100 g of Satsuma mandarin oranges. 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.[12] The CO_2 emissions attribute was at the levels of 20 g, 30 g, and 40 g per 100 g of Satsuma mandarin oranges. These levels were based on the life cycle assessment (LCA) because it was found that the amounts of CO_2 emitted in the LCA process differed for different food products. Our use of the LCA comprised four stages: production, fruit sorting and box packing, transportation, and packaging.[13] Table 1 displays the CO_2 emissions calculated in each process, which is referred to by Nemoto (2007).

[9] Two men did not take them home.

[10] We used the goku-wase, a type of Satsuma mandarin orange, in this study. Its color was of a bluish-orange tinge. The taste was sour as compared to other types of Satsuma mandarin oranges. The sugar content in it was approximately from 9 to 11 brix. For more details on Satsuma mandarin oranges, see Morton (1987).

[11] In the case of the 2007 data obtained from the Ministry of Agriculture, Forestry and Fisheries in Japan, the largest amount of goku-wase Satsuma mandarin oranges is available in Saga prefecture; the second largest, in Kumamoto prefecture; the third largest, in Ehime prefecture; and the fourth largest, in Wakayama prefecture. In our study, we did not use the goku-wase variety of Satsuma mandarin oranges from Saga prefecture because their appearance is more bluish than those in the other prefectures and they are less common in Osaka prefecture.

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

[13] In our study, we do not add the amount of CO_2 emissions in a supermarket and a store because there are a lot of other goods there.

Table 1 is around here

2-3. Design of the choice experiment

In this study, the D-optimal design approach for choice experiments was adopted based on a multinomial logit model in this study. The reason for this choice is twofold. First, the D-optimal design can extract the maximum amount of information from a respondent regarding the number of attributes, attribute levels, and other characteristics of a survey, such as cost and the length of the survey (Carlsson and Martinsson, 2003). Second, the D-optimal design is implemented to maximize a chosen optimality criterion based on a pre-specified model. Besides the D-optimal design, the optimality criterion has A- and G-efficiency. We define D-efficiency as

$$\text{D-efficiency} = \left[|\Omega|^{1/K} \right]^{-1}$$

where K is the number of parameters to be estimated and Ω is the covariance matrix of a vector of parameters. In addition to D-efficiency, there are also several other criteria of efficiency such as A- and G-efficiency. We, however, use D-efficiency because it is less computationally burdensome and can be directly executed using any of the numerous statistical software packages that exist.[14]

As a result of executing the D-optimal design through Design-Expert 7.0 (Stat-Ease, Inc.), we created 24 choice sets. These choice sets were further randomly divided into 12 versions, i.e., each version of the questionnaire consists of a set of 12 choices. The respondents were asked to select their favorite Satsuma mandarin orange and the reason in each choice set. Then, they answered several other questions related to the ECCB questions and their socioeconomic characteristics.

2-4. Samples

We conducted the laboratory experiment at 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.[15] We conducted 15 sessions with 104 respondents from 4th to 9th November, 2008. Each respondent was allowed to participate in only one experimental session. The respondents earned 1,407 JPY on average. Each session lasted for approximately 60 minutes. The socioeconomic characteristics of the participants in the experiment are summarized in Appendix C.

[14] For more details about D-optimal design, see for example, Alpízar et al. (2003), Carlsson and Martinsson (2003), and Huber and Zwerina (1996), for examples.

[15] Residents were recruited through leaflets inserted in some Japanese newspapers (i.e., Mainichi, Asahi, Yomiuri, and Sankei).

3. Model structure

In this study, we use two methods to analyze the data samples. The first method is the conditional logit model 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 that decision makers choose the alternative that maximizes their utility, given a set of alternatives. The utility of an alternative for an individual (U) cannot be observed; however, it can 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 follows:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{1}$$

Hence, the probability that individual q chooses alternative i from a particular set J, which comprises j alternatives, can be written as the following:

$$P_{iq} = P(U_{iq} > U_{jq}; \textit{for all } j(\neq i) \in J) = P(\varepsilon_{jq} < \varepsilon_{iq} + V_{iq} - V_{jq}; \textit{for all } j(\neq i) \in J) \tag{2}$$

To transform the random utility model into a choice model, certain assumptions regarding the joint distribution of the vector of random error components is 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 conditional logit model (McFadden, 1974) can be obtained. In the conditional logit model, the choice probability in Equation 2 is expressed as

$$P_{iq} = \frac{\exp(\mu V_{iq})}{\sum_{j=1}^{J} \exp(\mu V_{jq})} \tag{3}$$

Further, assuming that the deterministic component of utility is linear and additive in parameters $V_{iq} = \beta' \mathrm{X}_{iq}$, the probability in Equation 3 can be rewritten as

$$P_{iq} = \frac{\exp(\mu \beta' \mathrm{X}_{iq})}{\sum_{j=1}^{J} \exp(\mu \beta' \mathrm{X}_{jq})} \tag{4}$$

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} are the explanatory variables of V_{iq}, normally including alternative-specific constants (ASCs); the attributes of alternative i and socioeconomic characteristics of individual q; and β' is the parameter vector associated with matrix X_{iq}

4. Results

First, we tested whether the two subsamples—young adults (i.e., people below 30 years) and adults (people above 30 years)—can be divided because Diamantopoulosa et al. (2003)[16] found that young people were more concerned about the environmental quality than others and that there was a difference between the young and old in terms of participation in green activities. Since there was a significant difference between them in the data by the likelihood ratio (LR) test at the 5% significance level,[17] we will focus on the two subsamples separately.

4-1. Environmental characteristics of subsamples

Here, we analyze the environmental characteristics of subsamples based on some variables concerning the environment, namely, ECCB, Label, and Eco_behavior. First, we explain the ECCB variables. They are based on ECCB questions chosen by the respondents in questionnaires, as shown in Table 2. The questions are designed to assess the ecological purchase behavior by asking respondents to rate the veracity of various statements with respect to their purchase behavior and its connection to environmental product attributes. Based on the responses to the questions, we use the fact analysis in order to conduct ECCB variables. This analysis estimates a small number of underlying constructs, following Variyam et al. (1990) and Johnston et al. (2001). The constructs account for a large percentage of the observed variation in the responses. The extraction method is used for a principal-component factor analysis of the response correlation matrix. The rotation method used is VARIMAX. Based on the threshold eigenvalue of one, the number of retained factors is two. Table 2 shows the results of the rotated VARIMAX factor matrix and two ECCB variables, Factors 1 and 2. Factor 1 is characterized by a high factor loading (with values in bold face in Table 2) for questions E3, E4, E5, E7, E8, and E9. A high loading implies that the respondents consider the statement to be less applicable. These statements tend to reflect the willingness to let the environment be harmed. Therefore, this factor is chartered as "purchases harmful to the environment" (denoted as HARMFUL). Factor 2 is characterized by a high factor loading for questions E1, E2, E6, and E10. These statements tend to reflect the purchasing behavior for a household appliance. High scores for this factor indicate the willingness to give up an appliance with the feature of energy conservation. Therefore, this factor is called "the willingness to waste energy" (denoted as WASTE_ENERGY).

Next, the Label variable represents the consciousness about the environment and

[16] Diamantopoulosa et al. (2003) investigated the consumer's environmental consciousness based on three environmental measures, namely, knowledge, attitude, and behavior, by a survey in the UK. The main results were that they could confirm a significant difference between the environmental consciousnesses across ages only.

[17] LR = –2[–1954.6444-(–758.2744–1170.9713)] = 50.7974 > chi-square (2) = 5.991.

comprises 24 ecolabels that aid the purchase of environmentally friendly goods and 11 ecolabels that serve as identifying marks, which are selected from the database of the Ministry of the Environment in Japan.[18] The Eco_behavior variable is used as actual environmental behavior and comprises seven questions on people's behavior in daily life (e.g., whether or not they use a plastic shopping bag and how they operate appliances like air conditioners and cars).

Table 3 shows the logit regression results of environmental characteristics. The independent value is a dummy variable taking on the value of 1 for young adults. The variables *Label* and *Eco_behavior* were estimated with significant and positive and negative signs, respectively. They imply that young adults are more knowledgeable about ecolabels than adults, whereas they display a less environmentally friendly behavior than them. The variables *Harmful* and *Waste_energy* were estimated with significant and negative and positive signs, respectively. This implies that young adults are less willing to let the environment be harmed than adults, whereas they are more willing to give up an appliance with the feature of energy conservation than adults. Therefore, since the results of the adults sample contradict those of the young adults sample, young adults and adults have different tendencies toward environmental knowledge and behavior.

Tables 2 and 3 are around here

4-2. The WTP for the reduction of CO_2 emissions and the choice reason

With respect to the conditional logit regression results in Table 4, the two variables, *Price* and *CDE* (carbon dioxide emissions), were estimated with significant and negative signs in all samples, implying that all the respondents prefer Satsuma mandarin oranges at a cheaper price and at lower levels of CO_2 emissions. The WTP estimate for the reduction of 1 g CO_2 emission per 100 g of Satsuma mandarin oranges in the young adults sample was lower than that in the adults sample, implying that people above 30 years value the reduction of CO_2 emissions. These results support those of Diamantopoulosa et al. (2003).

Next, with respect to the choice reason, as shown in Table 4, the variable *R_Price* was estimated with significant and positive signs in the adults sample, implying that they value price while selecting oranges. The variable *R_CDE* was estimated with significant and negative signs in young adults, implying that they do not value CO_2 emission while selecting oranges. Further, the variable *R_Appearance* was estimated with significant and negative signs in young adults, implying that they do not value the appearance of oranges while selecting them. Therefore, these results

[18] See http://www.env.go.jp/policy/hozen/green/ecolabel/f01.html.

suggest that people below 30 years do not select food based on CO_2 emissions and have less value for this, whereas people above 30 years have more value more for this, although there is not significant whether they select food based on CO_2 emissions.

Table 4 is around here

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5. Conclusion

The present study is the first research that estimates the WTP of CO_2 emissions in Satsuma mandarin oranges across ages. The following results are obtained: (i) the WTP for the reduction of 1 g CO_2 emissions per 100 g of Satsuma mandarin oranges is 0.417 JPY; (ii) people below 30 years, who are significantly conscious about the environment, do not choose Satsuma mandarin oranges based on CO_2 emissions and have less value for this; and (iii) people above 30 years, who are environmentally friendly, choose oranges based on price and have more value for this, although this implies that they do not relate food to CO_2 emissions.

This study suggests two possible directions for further research. First, our results showed that there was a significant difference in the tendency toward the selection of food based on CO_2 emissions and the value for CO_2 emissions across ages in consumers. With respect to environmental behavior, some previous studies have found a difference between ages.[19] However, this study could not ascertain the reason behind the significant difference between ages. Moreover, the results of the young adults sample were valid between the choice reason and value for CO_2 emissions. However, those of the adults sample were not. Therefore, it should be investigated as to how adults are influenced by the amount of CO_2 emissions when choosing food.

Second, since the sensory information obtained from the process of eating a food product affects consumer behavior more than other types of information (Prescott et al., 2002; Aoki et al., 2008), it is essential to compare the taste and/or nutrition of a food product with the consumer's environmental consciousness.

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[19] See Diamantopoulosa et al. (2003).

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References

Akter, S., R. Brouwer, L. Brander, and P. van Beukering., 2009. " Respondent uncertainty in a contingent market for carbon offsets." *Ecological Economics* 68: 1858-1863.

Alfnes, F., A. G. Guttormsen, G. Steine, and K. Kolstad., 2006. "Consumers' Willingness to Pay for the Color of Salmon: A Choice Experiment with Real Economic Incentives." *American Journal of Agricultural Economics* 88(4):1050–1061.

Alpízar, F., F. Carlsson, and P. Martinsson., 2003. "Using Choice Experiments for Non-market Valuation." *Economic Issues* 8: 83–110.

Aoki, K., J. Shen, and T. Saijo., 2008. "Consumer Reaction to Information on Food Additives: Evidence from an Eating Experiment and a Field Survey." ExpSS21 Working Paper EspSS-E-8.

Brouwer, R., L. Brander, P. van Beukering., 2008. ""'A convenient truth'':air passengers'willingness to pay to offset their CO_2 emissions." *Climatic Change* 90; 299–313.

Carlsson, F. and P. Martinsson., 2003. "Design Techniques for Stated Preference Methods in Health Economics." *Health Economics* 12: 281–294.

Diamantopoulosa, A., B. B. Schlegelmilchb, R. R. Sinkovicsd, and G. M. Bohlen., 2003. "Can Socio-demographics Still Play a Role in Profiling Green Consumers? A Review of the Evidence and an Empirical Investigation." *Journal of Business Research* 56: 465–480.

European Climate Exchange. Dec-08 the excel data "Prices and Volume: ECX EUA Futures Contract" at Historical data - ECX EUA Futures Contract in EUA Futures. Available at http://www.ecx.eu/index.php/EUA-Futures.

Grankvist, G. and A. Biel., 2007. "Predictors of Purchase of Eco-labelled Food Products: A Panel Study." *Food Quality and Preference* 18: 701–708.

Grankvist, G., U. Dahlstrand, and A. Biel., 2004. "The Impact of Environmental Labelling on Consumer Preference: Negative vs. Positive Labels." *Journal of Consumer Policy* 27: 213–230.

Harrison, G. W. and E. E. Rutström., 2008. "Experimental Evidence on the Existence of Hypothetical Bias in Value Elicitation Methods." in V. L. Smith ed, Handbook of Results in Experimental Economics. New York: Elsevier Science.

Hudson, D., K. Gallardo, and T. Hanson. "Hypothetical (Non) Bias in Choice Experiments: Evidence from Freshwater Prawns" Journal of Agricultural and Resource Economics, forthcoming.

Huber, J. and K. Zwerina., 1996. "The Importance of Utility Balance in Efficient Choice Design." *Journal of Marketing Research* 33: 307–317.

Johnston, R. J., C. R. Wessells, H. Donath, and F. Asche., 2001. "Measuring Consumer Preferences for Ecolabeled Seafood: An International Comparison." *Journal of Agricultural and Resource Economics* 26(1): 20–39.

Kruse, J.B. and M.A. Thompson., 2003. "Valuing Low Probability Risk: Survey and Experiment Evidence." Journal of Economic Behavior & Organization 50: 495-505.

Loureiro, M.L., and J. Lotade., 2005. "Do Fair Trade and Eco-Labels in Coffee Wake Up the Consumer Conscience?" *Ecological Economics* 53: 129– 138.

Louviere, J. J., D. A. Hensher, and J. D. Swait., 2000. *Stated Choice Methods: Analysis and Application.* Cambridge: Cambridge University Press.

Lusk, J. L. and T. C. Schroeder., 2004. "Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beefsteaks." *American Journal of Agricultural Economics* 86: 467–482.

MacKerron, G.J., C. Egerton, C. Gaskell, A. Parpia, and S. Mourato., 2009. "Willingness to pay for carbon offset certification and co-benefits among (high-) flying young adults in the UK." *Energy Policy* 37:1372–1381.

McFadden, D., 1974. "Conditional Logit Analysis of Qualitative Choice Behavior." In *Frontiers in Econometrics*, Zarembka P., ed., pp.105–142. New York: Academic Press.

Ministry of the Environment of Japan, 2008. Online. Available at http://www.env.go.jp/doc/toukei/contents/data/es200202.xls (in Japanese).

Morton, J., 1987. "Satsuma Mandarin Orange." Fruits of Warm Climates, Julia F. Morton, Miami, Florida. pp.142–145. Online. Available at http://www.hort.purdue.edu/newcrop/morton/mandarin_orange.html

Nemoto, S., 2007. "Change in Quality of Consumption and Environmental Burden—All-Year Consumption of Fresh-tomatoes and LCI Analysis—." *The Japanese Society of Household Economics* 26: 55–67 (in Japanese).

Prescott, J. and A. Young., 2002. "Does Information about MSG (monosodium glutamate) Content Influence Consumer Ratings of Soups with and without Added MSG?" *Appetite* 39: 25–33.

Variyam, J. N., J. L. Jorday, and J. E. Epperson., 1990. "Preferences of Citizens for Agricultural Policies: Evidence from a National Survey." *American Journal of Agricultural Economics* 72: 257–267.

Wiedmann, T. and J. Minx., 2008. "A Definition of 'Carbon Footprint'." Ecological Economics Research Trends, C. C. Pertsova, ed. Chapter 1, pp. 1–11. Online. Available at http://www.censa.org.uk/reports.html.

Appendix

Appendix A: An example of choice sets

	Satsuma mandarin orange A	Satsuma mandarin orange B	Satsuma mandarin orange C
Price (JPY)	35	25	45
Carbon dioxide emissions (grams)	30	20	20
I would choose…	□	□	□
The most important reason affecting my choice	□Price □Carbon dioxide emissions □Appearance □Others[the reason:]		

Appendix B: Instructions for 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}+ participation 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 the variety of Satsuma mandarin oranges—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. Here, since it is an example, the price levels of the three Satsuma mandarin oranges are indicated as "81," "99," and "54." The price of Satsuma mandarin oranges in each round of the experiment is less than the money you receive to buy it. 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 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 value 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. Here, for example, the price levels of the three Satsuma mandarin oranges are symbolized as "100," "131," and "164." 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 (participation fee)

+ {(200 JPY – the price of the Satsuma mandarin orange that you buy in round 1)

+ (200 JPY – the price of the Satsuma mandarin orange that you buy in round 2)

+...+ (200 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 C: Socioeconomic characteristics of the laboratory experiment sample

Characteristics	n	%
Gender		
Male	36	34.62
Female	68	65.38
Age (years)		
Below 20	3	2.88
20–25	35	33.65
25–30	6	5.77
30–35	5	4.81
35–40	12	11.57
Above 40	43	41.32
Occupation		
Full-time employee	9	8.65
Part-time employee	17	16.35
Self-employed	0	0
Housewife	35	33.65
Student	40	38.46
Other	2	1.92
No answer	1	0.96
Education background		
High school	12	11.54
College	5	4.81
University	71	68.27
Graduate school	14	13.46
Other	1	0.96
I do not want to answer it.	1	0.96
Total observation	104	100

Characteristics	n	%
Household size		
1 person	26	25
2 persons	11	10.58
3 persons	19	18.27
4 persons	32	30.77
5 persons	14	13.46
Above 6 persons	1	0.96
No answer	1	0.96
Household annual income (JPY)		
< 2,500,000	22	21.15
2,500,000–4,000,000	5	4.81
4,000,000–5,500,000	9	8.65
5,500,000–7,000,000	15	14.42
more than 7,000,000	36	34.62
I do not want to answer it.	14	13.46
No answer	3	2.88
Ratio of household monthly meal expenses to income		
< 5%	3	2.88
5–9.99%	14	13.46
10–14.99%	27	25.96
15–19.99%	18	17.31
20–24.99%	14	13.46
> = 25%	20	19.23
No answer	8	7.69
Total observation	104	100

Table 1. The CO_2 emissions based on life cycle inventory

Prefecture	Total CO_2 emissions (g/ Satsuma mandarin orange 100g)	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 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 100 g 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. Results of ecologically conscious consumer behavior (ECCB) questions and the rotated VARIMAX factor matrix

No.	Syntax	Average ECCB scale [a]	The rotated VARIMAX factor matrix	
			Factor1	Factor2
E1	I have purchased a household appliance because it uses less electricity than other brands.	2.5636 (1.0852)	0.0364	**0.8699**
E2	I have purchased light bulbs that are more expensive but that save energy.	3.2327 (1.2247)	0.1513	**0.8010**
E3	I will not buy products that have excessive packaging.	3.0485 (1.1524)	**0.5967**	0.1629
E4	If I understand the potential damage to the environment that some products can cause, I do not purchase these products.	2.3981 (0.9487)	**0.6861**	0.1248
E5	I have switched products for ecological reasons.	3.068 (0.9272)	**0.7458**	0.2063
E6	I have convinced members of my family or friends not to buy some products that are harmful to the environment.	4.02 (0.9236)	0.4261	**0.5695**
E7	Whenever possible, I buy products packaged in reusable containers.	2.9223 (0.9523)	**0.5770**	0.2505
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.	2.4563 (1.0685)	**0.7117**	0.0544
E9	I will not buy a product if the company that sells it is ecologically irresponsible.	2.8355 (1.0805)	**0.6247**	0.4048
E10	I do not buy household products that harm the environment.	3.0391 (1.1569)	0.3983	**0.6385**

Notes: Standard deviations are in parentheses. The bold face represents higher factor loading in each question.

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

Table 3. Logit regression results

Variables	Coefficient	Marginal effects
Label [a]	0.2407***	0.0568
	(0.0133)	
Eco_behavior [b]	-0.6549***	-0.1545
	(0.0274)	
Harmful	-0.1610***	-0.0380
	(0.0323)	
Waste_energy	0.8091***	0.1909
	(0.0342)	
Log likelihood	-1889.7664	
McFadden's R^2	0.2591	
Observations	3744	

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

[a] consists of 24 ecolabels which aid the purchase of environmentally friendly goods and 11 ecolabels that serve as identifying marks which is selected from the database of the Ministry of the Environment (

[b] shows the environmentally friendly behavior consists of 7 questions on people's behavior in daily life, e.g., whether or not they use a plastic shopping bag and how they operate appliances like air conditioners and cars.

Table 4. Conditional logit regression results in main effect and in each reason for the choice

Variables	Young adult		Adult	
Price	-0.1251***	-0.1300***	-0.0612***	-0.0622***
	(0.0138)	(0.0148)	(0.0077)	(0.0078)
CDE	-0.0266**	-0.0317***	-0.0425***	-0.0442***
	(0.0100)	(0.0097)	(0.0083)	(0.0085)
R_Price	-	0.1913	-	0.1830**
		(0.1807)		(0.0819)
R_CDE	-	-0.3008*	-	0.0683
		(0.1650)		(0.0924)
R_Appearance	-	-0.3176**	-	-0.0722
		(0.1619)		(0.0777)
Marginal willingness to pay (JPY)	0.213	-	0.694	-
Log likelihood	764.2555	-758.27444	-1172.7218	-1170.9713
McFadden's R^2	0.1708	0.1773	0.0669	0.0683
Observations	1584		2160	

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