Do Consumers Select Food Products Based on Carbon Dioxide Emissions?

Keiko Aoki, Kenju Akai

Do Consumers Select Food Products Based on Carbon Dioxide Emissions?

Keiko Aoki[1], Kenju Akai[2]

[1] Institute of Social and Economic Research, Osaka University, Osaka, Japan

k_aoki@iser.osaka-u.ac.jp

[2] Graduate School of Engineering, The University of Tokyo, Tokyo, Japan

akai@css.t.u-tokyo.ac.jp

Abstract. This study investigates whether consumers select foods based on the levels of carbon dioxide emissions by a real choice experiment. Respondents are asked to purchase one orange based on price and level of CO_2 emissions under no monetary incentives. The willingness to pay estimate for the reduction of 1g of CO_2 emissions per orange is significantly lower for the low environmentally conscious group than it is for the high environmentally conscious group.

Key words: carbon dioxide emissions, choice experiment, consumer preference for foods, survey, random parameter logit model

1 Introduction

Recently, the problem of greenhouse gases also has given rise to a new type of eco-label for a product's carbon footprint (hereafter referred to as CFP) as well as previous eco-labels as Green Seal (United States), Eco-Mark (Japan), Blue Angel (Germany), and Nordic Swan (Scandinavia). The CFP may provide more information to consumers than previous eco-labels as it indicates the amount of CO_2 emitted through the process from production to disposal. Indicating this quantity may benefit consumers in that they will be able to select goods with a higher environmentally quality than other eco-labels provide, enabling more environmental consciousness consumption. In previous studies on the effects of previous eco-labels, an emphasis has been placed on testing the effectiveness of eco-labeling on consumers choices, i.e. selection of products having such a label versus those without one as well as the weight consumers give to public certification. The effectiveness of eco-labeling has been shown to have a positive result, according to several previous studies which have analyzed such effectiveness using empirical analysis (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

[1] Seafood products were used in Wessells et al. (1999), Johnston et al. (2001), Teisl et al. (2002) and Brécard et al. (2009). Toilet paper, paper towels and detergents were used in Bjørner et al. (2004), and “greener” vehicles in Teisl et al. (2008).

Zilberman, 2006; Ibanez and Grolleau, 2008), and an experimental method (Cason and Gangadharan, 2002). Therefore, one may be able to extrapolate that attaching a label indicating the CFP also has a positive effect from the results of these previous studies. However, a question still remains: Do consumers prefer a lower amount of CO_2 emissions among the food products also which do not have merits as decreasing a running cost?

The present study reports on how consumers value indications of CO_2 emissions for Satsuma mandarin oranges (*Citrus unshiu* Marc.) as compared to price. A choice experiment (CE) was conducted in which respondents actually bought the oranges. The respondents were provided with the price and CO_2 emission based on the life cycle inventory of the orange and asked to purchase them in 12 rounds. After each round, they also selected the reason for their choice from among three factors: price, CO_2 emission, and appearance. After the CE, the respondents were also asked to answer general questionnaires related to ecologically conscious consumer behavior (hereafter referred to as ECCB) (Roberts, 1996), environmental knowledge about several eco-labels in Japan, environmental behavior of respondents in daily life, and their socioeconomic characteristics.

As for the rest of the paper, Section 2 explains the survey designs. Section 3 presents the results, and Section 4 proffers the conclusion.

2 Survey design

We conducted a survey based on the CE method. The design of the survey was as follows. As shown in Table 1, the three alternatives in the designated choice sets were Satsuma mandarin orange A, Satsuma mandarin orange B, and Satsuma mandarin orange C.[2] The attributes being tested were price and the 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 a Satsuma mandarin orange. The total number of rounds in one session was 12.

2.1 Products

We used Satsuma mandarin oranges[3] 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

[2] In the study, there is not an alternative "no purchase" because our purpose is to test whether consumers choose foods based on the amount of the CO2 emissions. The results of using this alternative were found by Lusk and Schroeder (2004) which the frequency of individual choosing it was greater in real condition.

[3] 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).

Table 1. 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:]		

utensils (e.g., a knife) when they have to be consumed, which influences the amount of the 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[4] at supermarkets and stores in the area.

The price attribute was 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.[5] The CO_2 emissions attribute was 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. Our use of the LCA comprised four stages: production, fruit sorting and box packing, transportation, and packaging.[6] Table 2 displays the CO_2 emissions calculated in each process, which is referred to by Nemoto (2007).

2.2 Questionnaire

The environmental factors used in this study consist of three factors.[7] First factor is environmental consciousness (hereafter EC). This factor consist of 10 questions that are selected from the consumers' ecological purchase behaviors scale (Roberts, 1996), which is designed to characterize the extent to which

[4] 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.

[5] 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.

[6] In our study, we do not add the amount of the CO_2 emitted during selling products in a supermarket and a store.

[7] They are as follows: 1) I have purchased a household appliance because it uses less electricity than other brands;2) I have purchased light bulbs that are more expensive but that save energy; 3)I will not buy products that have excessive packaging; 4) If I understand the potential damage to the environment that some products can cause, I do not purchase these products; 5) I have switched products for ecological reasons; 6) I have convinced members of my family or friends not to buy some products that are harmful to the environment;7) Whenever possible, I buy products packaged in reusable containers; 8) When I have a choice between two equal products, I always purchase the one that is less harmful to other people and the environment; 9) I will not buy a product if the company that sells it is ecologically irresponsible; 10) I do not buy household products that harm the environment.

Table 2. 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.

environmental concerns influenced respondents' purchasing behavior. The scale is five-point likert-type scales such that they run from 1, which denotes that I "never agree", to 5, which denotes that I "always agree".

Second factor is the 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.[8] The respondents are asked to answer the number of the labels as possible as they know.

Third factor is environmental behavior in daily life (hereafter EB), the effect of which is estimated using seven questions. Of these, six questions evaluate consumer's behaviors in daily life and the seventh one is alternative "others". The respondents are asked to answer the number of the behavior as possible as they do in daily life.

2.3 Samples

The respondents were recruited from among the neighborhood residents from 10,000 households around

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

the university.[9] We gathered 212 participants and conducted survey in March 2012. The participation fee of the survey was 1000 JPY.

3 Results

Here, we divide each environmental factor into two groups by the median. The two groups under EC are defined as the high group, which consists of respondents whose responses are more than the median synthesis scale of 30 (Sd. = 7.349) in pooled, and the low group, which comprises the other respondents. The median number of total scales per respondent is 35 (Sd. = 3.771) and 26 (Sd. = 5.262) in high and low groups, respectively. In the EK, the high group includes respondents whose responses are more than the median number of twelve (Sd.=3.533) in pooled, 15 (Sd.= 1.891) in high group, and 10 (Sd.=2.230) in low one. In the EB, the high group includes respondents whose responses are more than the average number of 4 (Sd.=1.289) in pooled, 5 (Sd.= 0.483) in high group, and 3 (Sd.=0.840), which excludes question 7 as others.

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. Subsequently, we consider the hypothesis of equal utility parameters among the high group, low group, and pooled data for each environmental factor. We apply the likelihood ratio (LR) test suggested by Swait and Louviere (1993) in order to test these hypotheses by using the log likelihood values obtained by estimating main effect results in the Random Parameter logit model. The LR test shows that the hypothesis that the vector of common utility parameters is equal across groups for each factor can be rejected only for the EC factor.[10] The results for these two groups will only be analyzed for the EC factor.

With respect to the Random Parameter logit regression results in main effect as shown in Table 3, two variables, *PRICE* and *CDE*, were estimated to be statistically significant and negative signs, implying that all the respondents prefer Satsuma mandarin oranges at a cheaper price and at lower levels of CO_2 emissions. The cheaper price result supports the results of Prescott et al. (2002), which found that Japanese consumers particularly valued price. The marginal WTP estimate for the reduction of 1 g of CO_2 emissions per orange was 0.642 JPY in high environmental consciousness group and 0.286 JPY in low group, respectively.

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

[10] In RPL model also, the results by the LR test were as follows: LR*EC* = -2(-1107.619 - (-545.345 - 550.968)) = 22.612; LR*EK* = -2(-1107.619 - (-553.594 - 552.000)) = 4.050; LR*EB* = -2(-1107.619 - (-639.083 - 467.007)) = 3.058. Therefore, Only LR*EC* statistics in both models were larger than 5.911 (i.e., the critical value of the distribution at the 5% significance level on 2 degrees of freedom).

Table 2. The random parameter logit regression results for high and low environmentally conscious groups

Variables	Definition	RPL model				RPL model interactions			
		High		Low		High		Low	
		Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation	Coefficient	Standard deviation
Fixed parameter									
Price	Price of Satsuma mandarin oranges:25, 35, and 45 JPY per orange	-0.09*** (0.00)	-	-0.11*** (0.00)	-	-0.09*** (0.00)	-	-0.11*** (0.00)	-
Random parameter									
CDE	The amount of carbon dioxide emissions: 20, 30, and 40 gram per orange	-0.06** (0.00)	0.00 (0.02)	-0.03*** (0.00)	0.00 (0.02)	-0.07*** (0.01)	0.00 (0.02)	-0.03*** (0.00)	0.00 (0.03)
An interaction terms of CO_2 with socioeconomics chacteristics									
CDE × Female	An interaction term of CO_2 with a dummy variable that is equal to 1 if the respondent is female.					-0.02* (0.01)	-	-0.01 (0.01)	-
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.					0.03*** (0.01)	-	0.02* (0.01)	-
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					0.01 (0.01)	-	-0.02* (0.01)	-
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					0.00 (0.01)	-	0.02* (0.01)	-
Marginal willingness to pay (JPY)		0.64 [0.63;0.64]		0.28 [0.27;0.29]		-		-	
Log likelihood		-1228.26		-1046.81		-1100.43		-900.18	
McFadden's R^2		0.17		0.19		0.18		0.19	
Observations		1356		1188		1356		1188	

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

Next, with respect to the choice reason in main effect with interact, the variables CDE×Female and CDE×Old in high group were estimated to be statistically significant as well as negative and positive signs, respectively. They imply that female prefer to less the CO_2 emissions as compared to male and that above 40 years olds do not prefer to do them as compared to others. Meanwhile, the variables CDE×Old and CDE×High Income in low group were estimated to be statistically significant as well as positive and negative signs, respectively. They imply that above 40 years olds do not prefer to less the CO_2 emissions as compared to others and that people with high income prefer to do them as compared to them with low income.

4 Conclusions

The present study researches estimated WTP for CO_2 emissions regarding oranges before the CFP starts in Japan and the socioeconomics characteristics of those people who show an environmental consciousness for foods displaying the amount of CO_2 emitted over the product's lifecycle. The results imply that Japanese consumers prefer reducing CO_2 emissions through food purchases also, though they may not select fresh foods based on CO_2 emissions. This conclusion supports Bougherara and Combris (2009) such that consumers preferred food characteristics such as taste or appearance to environmental protection.

References

Amacher, G., Koskela, E., Ollikainen, M., 2004. Environmental quality competition and eco-labeling. J. Environ. Econ. Manage, 47, 284–306.

Bjørner, T.B., Hansen, L.G., Russell, C.S., 2004. Environmental labeling and consumers' choice-an empirical analysis of the effect of the Nordic Swan. J. Environ. Econ. Manage. 47, 411-424.

Bougherara, D., Combris, P., 2009. Eco-labelled food products: what are consumers paying for? Eur. Rev. Agric. Econ. 36(3), 321-341.

Brécard, D., Hlaimi, B., Lucas, S., Perraudeau, Y., Salladarré, F., 2009. Determinants of demand for green products: An application to eco-label demand for fish in Europe. Ecological Econ. 69, 115-125.

Cason, T., Gangadharan, L., 2002. Environmental labeling and incomplete consumer information in laboratory markets, J. Environ. Econ. Manage. 43, 113-134.

Hamilton, S. F., Zilberman, D., 2006. Green markets, eco-certification and equilibrium fraud, J. Environ. Econ. Manage. 52, 627–644.

Ibanez, L., Grolleau, G., 2008. Can ecolabeling schemes preserve the environment? Environ. Res. Econ. 40, 233–249.

Johnston, R. J., Wessells, C. R., Donath, H., Asche, F., 2001. Measuring consumer preferences for ecolabeled seafood: an international comparison, J. Agric. Res. Econ. 26(1), 20–39.

Kirchhoff, S., 2000. Green business and Blue Angels: a model of voluntary overcompliance with asymmetric information. Environm. Res. Econom. 15 (4), 403–420.

Lusk, J. L., Schroeder, T. C., 2004. Are choice experiments incentive compatible? A test with quality differentiated beefsteaks. Amer. J. Agr. Econ. 86, 467–482.

Morton, J., 1987. Home page (Satsuma Mandarin Orange, Fruits of Warm Climates, Julia F. Morton, Miami, Florida. pp.142–145). 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 Econ. 26, 55–67 (in Japanese).

OECD, 2005. Effects of eco-labelling schemes: compilation of recent studies. Joint Working Party on Trade and Environment, COM/ENV/TD(2004)34/FINAL.

Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., Stevens, R., 2002. Motives for food choice: a comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. Food Qual. Prefer. 13, 489-495.

Roberts, J. A., 1996. Green Consumers in the 1990s: Profile and Implications for Advertising. Journal of Business Research. 36, 217–31.

Teisl, M.F., Roe, B., Hicks, R.L., 2002. Can eco-labels tune a market? Evidence from dolphin-safe labeling. J. Environ. Econ. Manage. 43 (3), 339–359.

Teisl, M.F., Rubin, J., Noblet, C.L., 2008. Non-dirty dancing? Interactions between eco-labels and consumers, J. Econ. Psychology. 29, 140–159.

Wessels, C.R., Johnston, R.J., Donath, H., 1999. Assessing consumer preferences for ecolabeled seafood: the influence of species, certifier, and household attributes. Am. J. Agric. Econ. 81 (5), 1084–1089.