Consumer Perceptions of Climate Changes and WTP for Mandatory Implementation of Low Carbon Labels: The Case of South Korea

Hyeyoung Kim, University of Florida, kim1978@ufl.edu

Lisa A. House, University of Florida, lahouse@ufl.edu

Tae-Kyun Kim, Kyungpook National University, tkkim@knu.ac.kr

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014.

Copyright 2014 by Hyeyoung Kim, Lisa A. House, and Tae-Kyun Kim. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Consumer Perceptions of Climate Changes and WTP for Mandatory Implementation of Low Carbon Labels: The Case of South Korea

Abstract

Voluntarily implemented carbon labels have shown that there is a lack of motivation by companies to develop technology to reduce carbon emissions. This study examined consumer values for mandatory carbon labels in South Korea. Considering the altruistic nature of carbon labels, we asked about individuals' perceptions about the impact of climate change on their personal lives to measure consumer preference for carbon labels. Significant preference for mandatory carbon labels reflected Koreans' high level of concern about climate change. As an increasing number of consumers feel the impact of climate change, the gap of WTPs between low carbon labels and carbon measured labels is sufficient. The lower value of low-carbon labels as compared to GM labels indicates that consumers' guilt is not an appropriate strategy with carbon labels.

Introduction

Climate change due to high levels of greenhouse gas (GHG) emissions in the atmosphere has become an important issue in the world. Global warming threatens to raise sea levels, exterminate species, and threaten food security (Cox, Betts, Jones, Spall, & Totterdell, 2000; Vitousek, 1994). In response, the international community adopted the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 as the global legal policy framework and agreed to the Kyoto Protocol in 1997 as realistic rules for implementation. More recently, the Intergovernmental Panel on Climate Change (IPCC) pointed out human activities as one of the main causes for global GHG emissions, especially industrial activities (the Fourth Assessment Report 2007). In response to this, countries, retail chains or third party-non-government organization- in the World have established several carbon labels to inform consumers of the environmental impact of the products they consume daily to help them to act ecologically.

The main role of product labels is to turn "credence" attributes into "search" attributes. This new information may influence consumer product decisions to maximize their utility given price and quality if consumers perceive the information as valuable. Consumers who purchase products with carbon labels may obtain high utility in terms of public satisfaction rather than private satisfaction through participating in the reduction of carbon emission and helping global warming. In some cases, low carbon products such as cars and appliances may directly increase private utility of consumers by reducing spending on gas or electricity. On the other hand, producers or retailers may be interested in the label as a method of increasing profit through product differentiation. However, Tesco, a retailer in the U.K. reported that they would stop presenting carbon labels due to the cost of maintaining the labels (Quinn, 2012). This indicates that consumers' must value the label

for success of carbon labels in the market.

Carbon labels are voluntarily adopted in most countries. Gadema and Oglethorpe (2011) pointed out the limited effect of voluntary systems on reduction of carbon emission. Under the voluntary system, consumers may have unbalanced information in a same product bundle which may hinder the consumer's ability to the information and maximize utility. If consumers do not value this, producers may not have a strong motivation to invest in improving technology to reduce carbon emission. If the system is mandatory, consumers may have full information about all products in a category and may purchase a low-carbon product at prices that could stimulate producers to invest and develop technology to compete in the market.

Due to growing interest in this issue, many researchers have attempted to understand consumer perception of carbon labeling and attitude about climate change (Kemp, Insch, Holdsworth, & Knight, 2010; Kim, 2011; Ministry of Environment, 2007 & 2008; Upham, Dendler, & Bleda, 2011). This study seeks to further the literature regarding Korean consumers. Korean consumers may be relatively sensitive to environmental disorders compared to other countries due to increasing air pollution in Korea. In particular, increasing concerns about particulate matter (PM) 10 and PM 2.5 stimulate consumers to fear for the air safety. For eight years, from 2001 to 2008, high-PM10 episodes, defined as days in which the 24 hours PM10 mean exceeds 100mg m^{-3}, occurred 254 times in Seoul, Korea (Lee, Ho, & Choi, 2011). The negative impact of PM10 and PM 2.5 on human health has been reported (Dockery, & Pope, 1994; Harrison, & Yin, 2000; Englert, 2004). The United States Environmental Protection Agency (US-EPA) also warns of the potential health problems of PM for human lungs and heart.

A choice experiment (CE) analysis was used to estimate the value of carbon labels

depending on levels (measured and low carbon labels) and types of implementation (voluntary and mandatory low-carbon labels). In order to compare voluntary low-carbon labeling, we examined contingent mandatory low-carbon certification in the study. Consumer preference for carbon labels may vary by individuals' attitudes about climate change. The impact of climate change on individuals' lives was measured to predict the effect of individuals' attitudes toward climate change on preference. Consumers who strongly perceive the impact may be willing to pay extra to purchase products with low carbon labels and may prefer mandatory carbon labels. We selected fresh apples to derive policy implications of availability of low carbon production in agricultural products, since South Korea will expand carbon labeling to agricultural and livestock products starting in 2014.

Carbon Labeling

Global carbon labels

Introducing carbon labeling has symbolic meaning in developing world economics which implies that international leaders seek not only quantitative growth but qualitative growth of the world economy by considering global environment change. Unlike Eco Labels providing qualitative emission information of products, most carbon labels are designed to show quantitative emissions of carbon or GHG equivalent while a product is grown, manufactured, transported, used, and disposed. Despite controversial problems related to interpretation of the numerical values on carbon labels (Upham, Dendler, & Bleda, 2011), carbon emissions must be reflected by consumers' high level of concern for climate change. Selected carbon labels are shown in Table 1.

The first carbon labeling in the World was the Carbon Footprint labels created by the

Carbon Trust in the U.K in 2006. The Carbon Trust offered two types of Carbon Footprint labels, Reducing CO_2 Label and CO_2 Measured Label. The Reducing CO_2 Label certifies that companies have committed to reduce the level of CO_2 emissions resulting from the production and distribution of the products. The Carbon Trust requires re-certification of the Reducing CO_2 Label every two years. When it is re-certified, companies must prove that they have reduced the amount of CO_2 emissions. The CO_2 Measured Label only indicates that the footprints of the products are accurately measured. Both certifications must meet the requirements in the PAS 2050 and/or the WBCSD- WRI GHG Protocol Product Standard.

Supermarket channels in European countries created Carbon labels to inform consumers of the environmental impact of the products in response to global trends. Carbon labels may also promote a positive image of the supermarket by showing their desire to take care of our environment. In France, the Casino initiated a carbon labeling program called Indice Carbone in 2011 which provides quantitative CO_2 emissions, recycling information and additional information about the environment impact of use and disposal of products. In Switzerland, Migros introduced a carbon label called Climatop comparing carbon emissions to that of similar items. Products displaying Climatop indicate that the product's emissions are 20% lower those of its counterparts within the same product category.

In the USA, Carbonfund.org, a nonprofit provider of climate solutions, created a label called Certified Carbon*Free* in 2007. Products obtain the Carbon*Free* label when they meet the standards of PAS 2050:2008, ISO Standard 14044:2006 or WBCSD-WRI Greenhouse Gas Protocol for corporate GHG reporting. Also, products are qualified for the Carbon*Free* product certification program as long as the products have received the Carbon Trust and the Carbon Pollution Reduction Scheme developed by the Australian Government. Aside from Carbon*Free*, the Energy Star label provides energy efficiency information for

appliances. Murry and Mills (2011) estimated that Energy Star appliances are associated with carbon emission reductions of about 1.1 million metric tons per year.

In Japan, the Japan Environmental Management Association for Industry (JEMAI) started new Carbon Footprint of Products (CFP) programs based on ISO 14067 in 2012. The main features of CFP programs are CFP- Product Category Rule (PCR) certification, CFP verification, and verification of Emission Factors conducted by third party experts.

Table 1. Selected Carbon Labels by Country

Reducing CO2 Label (UK)	Indice Carbone (France)	Climatop (Swiss)	Certified Carbon*Free*™ (US)	CFP mark (Japan)

Carbon labels in South Korea

South Korea introduced a carbon labeling system to daily household supplies and home appliances in February 2009 in order to reduce GHG emissions by leading consumers to consume low carbon products and by encouraging companies to develop new technology which can reduce emission levels. Government agents issue two different levels of carbon labeling: Carbon-Emission Certification (CEC) in Figure 1 (a) and Low-Carbon Product Certification (LCPC) in Figure 1 (b). The original labels were modified with English in Figure 1[1]. Similar to the CO*2* Measured Label of the Carbon Trust, the CEC is issued if products are officially examined for emission levels and meet standard GHG emission levels. The LCPC is issued for a product which already obtained the CEC, if the company

[1] Please refer the website of the Korea Environmental Industry & Technology Institute for the original labels: http://www.keiti.re.kr/action.do?mid=1010409000

successfully develops techniques to reduce a certain amount of GHG emissions to produce that product. The LCPC is similar to the Reducing CO_2 Label of the Carbon Trust. In 2013, only 75 products obtained LCPC out of 707 total certified products (Korea Environmental Industry & Technology Institute). This indicates that companies are less likely to invest in developing new technology to reduce GHG emissions.

a. Carbon-Emission Certification

b. Low-Carbon Product Certification

Figure 1. Korean carbon labeling

Literature Review

Choice experiments (CE) have widely been used to measure consumer willingness to pay for attributes of products. In particular, CE has been used to examine values of different types of labels such as nutritional labels, health labels, ingredient labels, GMO labels, country of origin labels and food mileage labels. Although Lusk and Schroeder (2004) pointed out the hypothetical bias in a CE, CE is relatively cost effective and enables large coverage compared to experimental auctions, which may reduce hypothetical bias. Studies on carbon labels have mainly found that consumers valued low carbon emissions and had higher WTP for low carbon products than high carbon products.

Aoki and Akai (2013) performed a real choice experiment to compare consumer willingness to pay (WTP) for the reduction of CO_2 emissions for Satsuma mandarin oranges based on consumer attitudes toward the environment in Japan. They used three environmental factors: environmental consciousness (EC), environmental knowledge (EK) and environmental behavior (EB) in daily life. Consumers were categorized into two groups

with high and low attitudes of EC, EK and EB. The results of the random parameter logit model indicated that only environmental consciousness led to significant differences in respondents' purchase behavior of oranges based on carbon emission levels. Consumers belonging to a high EC group were willing to pay over 2.2 times higher than consumers in a low EC group for the reduction of 1g of CO_2 emissions per orange.

Michaud, Llerena, & Joly (2013) were interested in determining whether consumer values for GMO products related to environmental attributes (altruistic) or sanitary attributes (selfish). To distinguish, they used non-food products (roses) to measure consumers' WTP. They conducted a discrete choice experiment with real purchases of roses associated with an eco-label and a carbon footprint in France. The results of the mixed logit model indicated that consumers valued significant environment attributes and the value of a low-carbon footprint was considerably greater than eco-labels (low fertilizer). The premium for roses with a low-carbon footprint was approximately 2.4 times larger than eco-labeled roses.

Loureiro, McCluskey, & Mittelhammer (2002) measured American consumers' WTP for eco labeled apples using a double-bounded logit model. They used the eco-label certified by The Food Alliance (TFA), a non-profit third-party certifying organization based in Portland, Oregon. They found that the mean premium for eco-labels was low, only 5% of market prices, they suggested may be a result of ambiguous to consumers of the labels.

In South Korea, research has shown that over 90% of consumers aged 13 years and over were aware of climate change and perceived the condition as serious (Ministry of Environment, 2007 & 2008). However, consumers were relatively less likely to use carbon labels as a source of information to obtain items to reduce carbon emissions in daily life (Kim, 2011). Kwack (2011) found that only one third of consumers in Korea were willing to purchase products with carbon labels when the price was 5% higher than market prices. Lee

(2012) found higher numbers, using the contingent valuation method to measure consumers' WTP for carbon labeled rice, Lee found consumers willing to pay about 46% more for carbon labeled rice than market prices.

A framework of climate changes perceptions and carbon labeling preferences

Consumer preferences about carbon labels or products produced in an ecological friendly manner may depend on their perceptions about climate change. Individuals who perceive the impact of climate change on his/her personal life may have a higher preference for carbon labels and be willingness to pay more to purchase products with labels. The degree of consumer concern about climate change, as well as demographics, may be important factors in measuring the probability of consumer perception about climate change on their personal life. In addition, respondents' living area may be an important indicator to measure the probability. Jang, Lee, & Lee (2012) found that the level of PM10 varied by city: of 10 major cities in South Korea, Seoul ranked the third highest in PM10 levels and Daegu ranked the sixth highest in PM10 levels. Figure 1 frames the modeling of individuals' perceptions of climate change and apple purchases based on various grades, prices and carbon labels. The probability that respondents agreed and strongly agreed that climate change influenced their personal lives was calculated. The predicted probability was included in the apple purchase model as interactions with carbon labels. The interaction terms indicate preferences for carbon labels of individuals who perceived the impact of climate change on their personal lives.

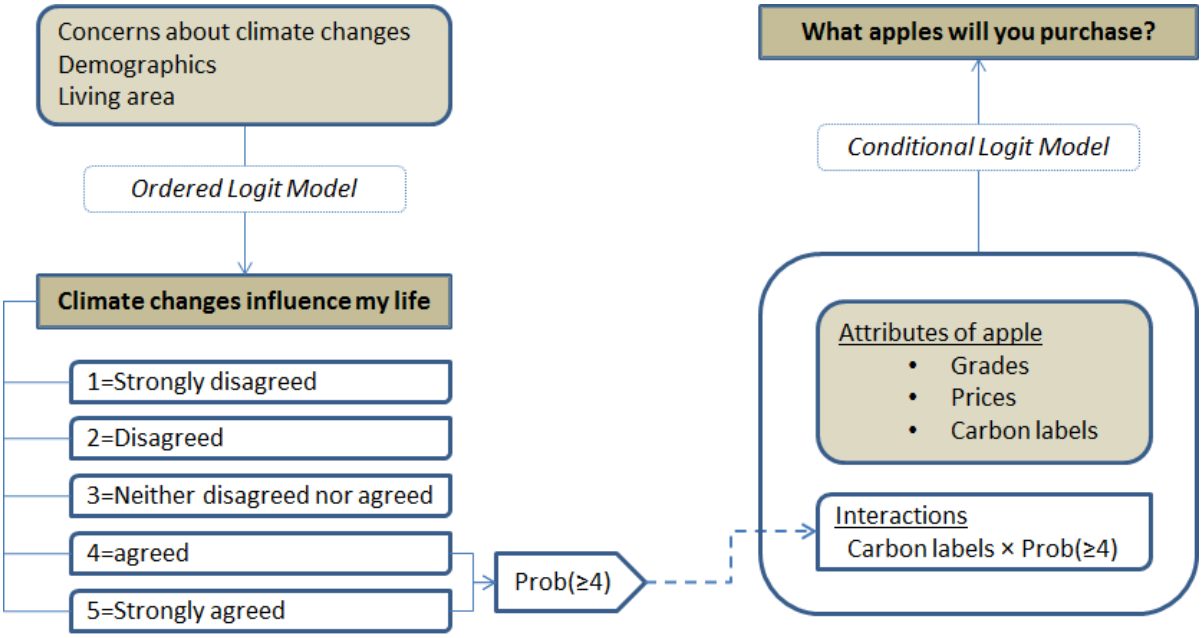


Figure 2. Modeling perception of climate changes and apple purchases

Korean consumer survey of climate changes and carbon labels

A consumer survey was conducted with primary shoppers in households living in urban areas in South Korea. The survey questionnaire was designed for face-to-face interviews and consisted of three parts. In the first part, participants were asked to indicate their perception toward climate change and attitude about their effort to reduce climate change. In the second part, participants indicated their socio-economics, gender, age, level of education attained, income and living area. In the third part, interviewers explained the current carbon labeling system. Lastly, participants faced six CE questions. We designed choice experiments (CE) using three attributes of fresh apples: price, quality and carbon labeling to measure WTPs of apples. Four price levels represent retail prices of Fuji apples depending on the quality in season for 5kg, which is the most popular size: \$18, \$26, \$35 and \$44[2]. South Korea grades quality standards of fresh apples with three classes depending on

[2] In the survey, we used South Korean Won (₩) instead of US Dollar (\$). Average exchange rate of August in 2012 was used to convert the unit (₩1,133/\$).

external (size, shape, color etc.) and internal (sweetness, juiciness etc.) attributes: superior, good and marketable quality. Two levels of current carbon labeling (CEC and LCPC) and a mandatory low-carbon certification (MLCC) were included in the choice experimental design, which also included a no carbon labeling baseline. In each choice set, respondents will select one of two hypothetical apples or select a 'None of these' option as shown in Table 2. This feature ensured that respondents were never forced to purchase an apple. A large number of hypothetical apples could be constructed to make two alternatives using three attributes and their various levels. Based on a D-efficiency criterion, 144 alternatives provided 100% efficient design. Despite the high efficiency, the number of designs will create many different versions of survey questions. To reduce participants' burden to respond and to collect precise information, the 36 profiles were optimally sorted into six blocks which achieved a D-efficiency score of 98.6. Six types of questionnaires were randomly distributed to respondents. Optimal profiles of the attributes were drawn using orthogonal design and obtained 36 profiles shown in Appendix.

The survey was conducted in Daegu, which is the third largest city in Korea, and in Seoul which is the capital city of Korea, with trained interviewers in August, 2012. The interview was conducted in randomly selected grocery stores and respondents were also randomly selected from the selected grocery stores. We obtained 186 valid observations.

Table 2. A modified question example of choice experiment

	Apple 1	Apple 2	
Grade	Good	Superior	
Carbon labels	Mandatory Low Carbon Certification	Carbon-Emission Certification	None of these
Price	$35/5kg	$26/5kg	
I would choose…	□	□	□

Sample Descriptions

Respondents' characteristics and average attitudes toward climate change are shown in Table 3. The table also provides census data for Seoul and Daegu in the last column. Compared to census, respondents were young, female, educated and residents out of Seoul. Since the target samples were primary shoppers in households, the high percentage of female respondents was acceptable. To decrease bias due to the under-representation in the population, we used post-stratification to adjust the distribution gaps of age, education and residency.

Respondents indicated high levels of concern about climate change. Approximately 90% of respondents answered that they are very concerned or somewhat concerned about climate change. This result was comparable to the survey results conducted by the Ministry of Environment in which 90.5% of consumers indicated that global warming is very serious (Ministry of Environment, 2008). Over 57% of respondents agreed (strongly agree or agree) that climate change affected personal life. This implies that climate change is not only a national issue, but a private issue. Many individuals indicated willingness to change their behavior and activities to reduce climate change (about 78%). However, over 60% of respondents pointed out that there are many external factors which make their effort difficult. Overall, approximately 90% of respondents agreed that efforts to reduce climate change are very urgently required. To reduce climate change, about 87% of respondents agreed to reduce consumption of products which cause environmental pollution and about 55% of respondents indicated that they would pay more for products which reduce climate change.

Table 3. Sample Descriptive Statistics and Variable Description

Variable	Variable description and code[1)]	Sample (N=186)	Seoul and Daegu Census
Climate changes	=5 if Respondents strongly agreed that climate changes influence my	6.5%	-
	=4 if life	51.1%	
	=3 if Respondents agreed	25.3%	
	=2 if Respondents neither agreed nor disagreed	16.1%	
	=1 if Respondents disagreed	1.1%	
Age	Respondent age (mean=39.9, standard deviation=12.1)	54.8%[2)]	42.1%[2)]
Gender	=1 if Male	32.3%	47.4%
Income	=1 if Monthly household income were $3,500 and over	51.6%	$3,600[3)]
Education	=1 if Respondents completed 2yr or 4yr college	75.8%	51.8%
Seoul	=1 if Respondents live in Seoul	57.5%	80.4%
Hconcern	=1 if Respondents indicated strongly concerns about climate changes	33.3%	-
Mconcern	=1 if Respondents indicated moderately concerns about climate	57.5%	-

1) Alternative code for the dummy variables, gender, income, education, Seoul, hconcern and mconcern is '0'.
2) The described percentages are consumers under 40 years of age.
3) Monthly average household income in 2013 (Statistics Korea)

Estimates of ordered logit model for perceptions of climate change

Participant perceptions about the impact of climate change on their personal lives were measured with 5-point scales (1 was strongly disagree and 5 was strongly agree, J=5). For convenience, define W as respondents' characteristics such as age, gender, income, education, residency (Seoul or not) and two levels of climate change concerns. From the estimated ordered logit model, we will have (J-1) unknown thresholds (α_j) and regression parameters (β) associated with W.

$$Y^* = \sum_{j=1}^{J-1} \alpha_j + W'\beta + \varepsilon,\ \mathrm{Y} = \sum_{j=1}^{J} j\, I(\alpha_{j-1} < Y^* \leq \alpha_j),$$

where Y^* is the latent variable measuring individuals' perceived impact of climate change on their personal lives and Y is the indicated ordered response. The thresholds α_j are cut-points on the latent variable used to differentiate changing points given that all the predictor variables are set at zero. The sign of the regression parameter β can be immediately interpreted as determining whether or not the latent variable increases with the regressor.

The corresponding estimated thresholds (α_j) and linear combination of between estimated parameters and variables ($W'\beta$) enter the ordered logit model with j indicating the five perception levels to obtain predicted probability:

$$\text{Prob}(\text{Y} \leq \text{j}|W) = \exp(\alpha_j + W'\beta) \Big/ 1 + \exp(\alpha_j + W'\beta)$$

$$\text{Prob}(\text{Y} > \text{j}|W) = 1 - \text{Prob}(\text{Y} \leq \text{j}|W).$$

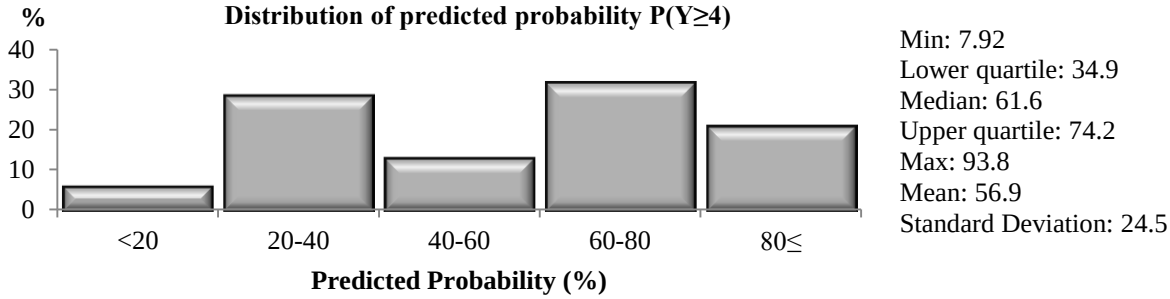
The results of estimated logit models are shown in Table 4. All demographic variables were not statistically significant at the 5% level, while respondents' living area and their degree of concern about climate change were significantly different from zero at the 5% level. The perceptions of the impact of climate change on participants' personal lives were not significantly different by age, gender, income and education. Participants living in Seoul were more likely to perceive the impact of climate change on their lives. Also, participants who were more concerned about climate change were more likely to perceive the impact of climate change on their life.

Marginal effects of variables were shown in the last five columns of Table 4. Respondents living in Soul were 27% more likely to perceive the impact than respondents living out of Seoul. Also, respondents who were strongly concerned about climate change were 34% more likely to perceive the impact than respondents who were not concerned at all. The signs of marginal effects have changed at the level that respondents agreed to the statement that climate change influences their personal lives (j=4). We calculated the predicted probability of individuals' perception of the impact of climate change on their personal lives for agreed or strongly agreed to the statement, Prob (Y≥4). The mean of predicted probability is 56.9%, ranged 7.9% to 93.8%. On average, 56.9% of individuals perceived the impact of climate change on their personal lives. As shown in the distribution

of predicted probability at the bottom of Table 4, the predicted probability has a bimodal distribution indicating that consumer perception of the impact of climate change on their personal lives was polarized.

Table 4. Estimated results of likelihood of climate change on private life

		Std.	Marginal Effect				
	Coefficient	Err.	P(Y=1)	P(Y=2)	P(Y=3)	P(Y=4)	P(Y=5)
Age	0.016	0.017	0.000	-0.002	-0.002	0.003	0.001
Gender	-0.314	0.365	0.001	0.036	0.039	-0.065	-0.011
Income	0.400	0.332	-0.001	-0.045	-0.050	0.081	0.015
Education	-0.030	0.422	0.000	0.003	0.004	-0.006	-0.001
Seoul	1.329**	0.333	-0.006	-0.161**	-0.148**	0.267**	0.048**
Hconcern	2.594**	0.586	-0.008	-0.231**	-0.272**	0.342**	0.168**
Mconcern	1.126**	0.518	-0.005	-0.134*	-0.130**	0.228**	0.040*
Cut1	-2.583**	1.050	-				-
Cut2	1.124	0.869					
Cut3	2.627**	0.917					
Cut4	6.222**	1.040					
N					186		
LR $\chi^2(8)$					45.04 (p-value< 0.05)		
Log likelihood					-104.289		



** and * indicates that the coefficients are significantly different from zero at 5% and 10% levels, respectively.

Estimates of conditional logit model for apple purchases

To better understand respondents' preferences with regard to carbon labeling, a conditional logit model was estimated using choice experiment information. The experiments are based on random utility theory and are consistent with Lancaster's theory of utility maximization which states that consumers demand attributes embodied in a good

(Louviere, Hensher, & Swait, 2000). Let U_{ik} bet the *i*th individual's utility of choosing *k*th alternative. The total utility can be divided into two components of a systematic component,V_{ik}, and a random component, ε_{ik}: $U_{ik} = V_{ik} + \varepsilon_{ik}$. Assuming the random component is independently identically distributed (i.i.d) with type I extreme value (Gumble) distribution leading to a logit model formulation (McFadden, 1974). The probability of consumer *i* choosing alternative *k* out of K options is

$$P(i = k) = \frac{\exp(V_{ik})}{\sum_{k=1}^{K} \exp(V_{ik})}$$

The systematic component includes five dummy variables, superior quality, good quality, CEC, LCPC and MLCC of product attributes and prices. We set marketable quality and no carbon labeling as baselines. Also, the model includes three interactions between individuals' perception of the impact of climate change on their personal lives and three carbon labels. We used the predicted probability of agreed and strongly agreed on the statement as an indicator of respondents' attitudes about climate change as shown in Figure 2. The systematic component model also includes a constant specific to the alternative 'None of these' to capture the average effect on utility when consumers do not purchase. The model was estimated using maximum likelihood estimation. From estimated parameters, consumers' willingness to pay was calculated with the negative of the ratio of attribute coefficients to price coefficients indicating the marginal rates of substitution (Louviere, Hensher and Swait, 2000).

The estimated results of the conditional logit model were shown in Table 5. The sign of an alternative specific constant indicated respondent utility decreased when they selected not to purchase apples. All estimated parameters were statistically significant at 5% levels and have expected signs, positive for quality and carbon labeling, and negative for

prices. This indicates that the attributes are important factors when consumers purchase apples. That is, higher quality of apples and products with carbon labels were preferred, while expensive apples were not preferred. Also, all signs of the interactions were positive which indicated that consumers who perceived the impact of climate change on their personal lives were more likely to select products with carbon labels or produced in an environmentally friendly way compared to respondents who did not. In other words, consumer perception about climate change is an important factor for the success of low carbon labels.

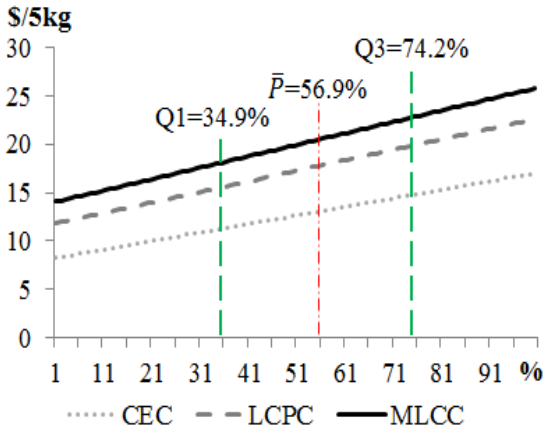
To compare consumer utility levels in monetary terms, WTPs were calculated as a ratio of attribute coefficients to price coefficients. Standard errors and confidence intervals were measured with the delta method. Higher levels of WTP reveal higher utility levels of consumers when they consume the products. WTPs for carbon labels compared to no carbon labels were calculated and the changes of WTPs over probability were specified in the last column of Table 5. As the probability that consumers perceived the impact of climate change on their personal lives increased, WTPs for carbon labels increased. At the mean of the predicted probability ($\bar{P} = 56.9$), an average WTP for a carbon emission certification was \$13.2, an average WTP for a low carbon product certification was \$17.9, and an average WTP for mandatory low carbon certification was \$20.7. Consumers who were in the upper quartile of predicted probability were willing to pay \$3.4~\$4.6 more for carbon labels than consumers in the lower quartile of predicted probability.

The marginal WTPs at the mean of predicted probability were shown in Table 6. Consumers were willing to pay about \$8 extra to purchase good quality apple instead of apples that were merely marketable quality. To purchase superior quality, consumers were willing to pay an extra \$5 over good quality. Price differences at retail market between good

quality and marketable quality are, on average, $6 to $9 in 2012 and 2013. Average respondents were willing to pay an extra $5 to purchase apples produced with low carbon product rather than carbon emission certifications. When the labels were mandatory, they were willing to pay an extra $7 to purchase apples produced with low carbon emission compared to carbon emission certification. Therefore, average respondents had high utility when low carbon labels were implemented as mandatory and the marginal WTPs were significant. This implied that consumers were ultimately interested in the reduction of carbon emission to alleviate the impact of climate change on their personal lives. Mandatory low-carbon labeling enables companies to develop technology to reduce GHG emissions.

Table 5. Estimated results of conditional logit model and willingness to pay for carbon labels

	Coefficients	Std. Err.	Willingness to pay for carbon labels by probability levels[2)]
ASC	-4.632**	0.319	
Good quality	1.137**	0.155	
Superior quality	1.869**	0.174	
CEC[1)]	1.167**	0.406	
LCPC[1)]	1.675**	0.392	
MLCC[1)]	1.991**	0.454	
Price	-0.00013**	0.000	
P*CEC	1.262*	0.653	
P*LCPC	1.557**	0.646	
P*MLCC	1.691**	0.741	
N	3348		
LR χ^2 (10)	1433.87	P-value<0.05	
Log likelihood	-508.118		



1) CEC, LCPC and MLCC indicate a carbon emission certification, a low carbon product certification and a mandatory low-carbon certification, respectively.
2) Willingness to pay was converted to U.S. dollars from South Korea Won (1,133 Won/$).

The significance of marginal WTPs varies depending on the probability of respondents perceiving that climate change impacts on their personal lives. Marginal WTPs

from carbon emission certification to low carbon product certification were significant, with the probability ranging 26% to 99%. Approximately 87.6% of respondents were in this range. Marginal WTPs from low carbon emission certification to mandatory low carbon certification were significant, with the probability ranging from 43% to 74%. Approximately 40.3% of respondents were in this range. In general, consumers significantly preferred reduction of carbon emissions to certification of carbon emission, while consumer preferences between voluntary and mandatory low carbon labels varied.

Table 6. Marginal willingness to pay

	Marginal WTPs ($/5kg)	95% Confidence interval ($/5kg)
By apple grades		
Marketable quality to Good quality	7.96**	5.98~9.94
Good quality to Superior quality	5.12**	2.98~7.26
By carbon label levels[1)]		
No Carbon labels to CEC	13.20**	10.60~15.80
CEC to LCPC	4.73**	1.98~7.48
LCPC to MLCC	2.75**	0.45~5.04

1) Marginal WTPs were calculated at the mean of predicted probability of likelihood of climate change on private life.
2) WTPs converted to US dollar from South Korea Won based on average exchange rates of at the time of data collections, August 2012, 1,133 Won/$.

Consumer WTPs for carbon labels would be comparable to WTPs for genetically modified organism (GMO) labels in terms of comparison of products with public and private attributes. Although carbon and GMO labels compound both attributes, carbon labels are relatively weighted on public attributes such as environmental protection, while GMO labels are closely related to private attributes such as potential/uncertain health risks. Many studies found that Korean consumers were willing to pay prices 50% to 130% higher to purchase non-GMO products instead of GMO products (Kim 2004; Kown 2003; Lee, Hong, & Kim 2012). Kim and Hong (2005) measured Korean consumer WTPs for non-GM apples

using choice experiment. They found that consumers discounted the value of GM apples approximately 52% compared to non-GM apples which was comparable to the premiums of non-GM apples with other studies. The premium of carbon labels was 30% to 60% depending on the quality of the apples. This indicated that consumer demand based on altruism (i.e., public products) is less than their demand based on selfishness.

Conclusions

Voluntarily implemented carbon labels have shown that there is a lack of motivation by companies to develop technology to reduce carbon emissions and hinder consumer choice due to unbalanced information of a same product bundle. The success of carbon labels in markets depends highly on consumer values due to the nature of public attributes. Based on a consumer survey with choice experiments, this study compared consumer preferences between mandatory and voluntary carbon labels while considering individuals' perceptions of the impact of climate change on their personal lives. An ordered logit model was used to measure probability of perceptions about the impact of climate changes on individuals' personal lives. The predicted probability was implemented in a conditional logit model to measure consumer preference for carbon labels based on levels of perception.

As consistent with previous studies, we found that consumers preferred low carbon labels to carbon measured labels. In addition, our findings suggested that consumers have a significant preference for mandatory low carbon labeling compared to voluntary labeling. Average marginal WTPs from voluntary low carbon labels to mandatory low carbon labels were $2.75 indicating that consumers have higher utility when they purchase mandatory low carbon labels. This result reflects consumers' high level of concern about climate change and their desire to curb the speed of global warming. Although consumer value for carbon

labels is a prior condition to the success of the program, the example of Tesco's decision to stop using carbon labels indicates that relying on consumer guilt is not sufficient. As Gadema and Oglethorpe (2011) suggested, the effective linkages between food policy and food market actors are required to achieve the ultimate goal of reducing carbon emission. In terms of the connection, a well-developed mandatory program would be a possible alternative.

This study provided that consumer perceptions about the impact of climate change on their personal lives was an important indicator to predict the success of carbon labels in the market. Similar to Aoki and Akai (2013)'s findings, consumers' environmental consciousness was significantly related to preference for carbon emissions. Respondents who strongly perceived the impact of climate changes on their person lives ($P(Y_i \geq 4) = 74.2$) were willing to pay extra \$3.4~\$4.6 to purchase the same apples with carbon labels as compared to respondents who weakly perceived ($P(Y_i \geq 4) = 34.9$). Consumers who were more exposed to risk of environmental disorder and who were concerned about climate change tended to strongly feel the impact. It seems that growing concerns about global warming and frequent occurrences of PM10 episodes in Seoul, South Korea are causing great consumer attention in curbing climate change. The pace at which climate change is occurring is faster than any change recorded in the past 65 million years (Diffenbaugh, & Field, 2013). This phenomenon will cause more consumers to be impacted by climate change and then spur consumers on to try to reduce carbon emission.

Consistent with Michaud, Llerena, & Joly (2013), we also found consumers' value of altruism for food products. However, consumer willingness to pay for public attributes was less than private attributes. Due to no exception of activities of agricultural production (Lal, 2004), producers, industries, government and scholars in agriculture and livestock sections may take into consideration this change for the future plan. To establish successful

settlement of the system, coherent food policy, incentive for producers and retailers and education for consumers are required.

References

Aoki, K. (2009). Do Consumers Select Food Products Based on Carbon Dioxide Emissions? Evidence from a Buying Experiment in Japan. ISER Discussion Paper No. 749. Available at http://dx.doi.org/10.2139/ssrn.1439432.

Aoki, K. & Akai, K. (2013). Do Consumers Select Food Products Based on Carbon Dioxide Emissions? *IFIP Advances in Information and Communication Technology* 398:345-352

Cox, P.M., Betts, R.A., Jones, C.D. Spall, S.A. and Totterdell, I.J. (2000). Acceleration of Global Warming Due to Carbon-Cycle Feedbacks in a Coupled Climate Model. *Nature* 408, 184-187.

Diffenbaugh, N.S. & Field, C.B. (2013). Changes in Ecologically Critical Terrestrial Climate Conditions. *Science* 341, 486-492.

Dockery, D.W. & Pope, III. C.A. (1994). Acute Respiratory Effects of Particulate Air Pollution. *Annual Review of Aerosol Science* 29, 421-444.

Englert, N. (2004). Fine Particles and Human Health-A Review of Epidemiological Studies. *Toxicology Letters* 149, 235-242.

Gadema, Z. & Oglethorpe, D. (2011). The Use and Usefulness of carbon labeling food: A policy perspective from a survey of UK supermarket shoppers. *Food Policy* 36, 815-822.

Harrison, R.M. & Yin, J. (2000). Particulate Matter in the Atmosphere: which particle properties are important for its effects on health? *The Science of the Total*

Environment 249, 85-101

Ministry of Environment. 2007. National Awareness on Climate Changes in South Korea (1st survey).

Ministry of Environment. 2008. National Awareness on Climate Changes in South Korea (2st survey).

Jang, J-H., Lee, H-W., & Lee, S-H. (2012). Spatial and Temporal Features of PM10 Evolution Cycle in the Korea Peninsula. *Journal of the Environmental Sciences* 21(2), 189-202.

Kemp, K., Insch, A., Holdsworth, D.K., & Knight, J.G. (2010). Food Miles: Do UK Consumers Actually Care? *Food Policy* 35, 504-513.

Kim, T-K. (2004). Consumers' Willingness to Pay for GM Food in Experimental Auction Market. *Kyung Je Hak Yon Gu*. 52(4), 121-140

Kim, T-K. & Hong, N-K. (2005). Measuring the Willingness to pay for Food-Safety Attributes. *Korea Journal of Agricultural Economics* 46(2), 181-196

Kim, J. (2011). Consumer Awareness about Climate Changes and Food Safety. *Korea Institute of Health and Social Affairs, Issue & Focus*, 117 Ho, ISSN 2092-7177.

Kown, O-S. (2003). Estimating the Willingness to Pay for the Non-GMO Agricultural Products: A contingent Valuation Study. *Korea Journal of Agricultural Economics*, 44(2), 111-131

Kwack, N-S. (2011). A Study on the Improvement of the Carbon Footprint Label on Food in Korea. *Health-welfare Policy Forum*, 172, 68-80.

Lal, R. (2004). Agricultural activities and the global carbon cycle. Nutrient Cycling in *Agroecosystems*, 70, 103-116

Lee, S-M. (2012). A Study on Consumers' WTP for Low-Carbon Agricultural Products

Certification. Unpublished thesis at the Kyungpook National University.

Lee, H-J., Hong, N-K., & Kim, T-K. (2012). Measuring Willingness to Pay for GM rice by Characteristics. *Korean Journal of Agricultural Management and Policy,* 39(2), 147-169

Lee, S., Ho, C-H., Lee, Y.G., Choi, H-J., & Song, C-K. (2013). Influence of transboundary air pollutants from China on the high-PK10 episode in Seoul, Korea for the period October 16-20, 2008. *Atmospheric Environment* 77, 430-439.

Loureiro, M.L, McCluskey, J.J. & Mittelhammer, R.C. (2002) Will Consumers Pay a Premium for Eco-labeled Apples? *The Journal of Consumer Affairs* 36(2), 203-219

Louviere, J.J., Hensher, D.A., & Swait, J.D. (2000). *Stated choice methods: Analysis and Application*. New York, U.S.: Cambridge University Press.

Lusk, J.L., & Schroeder, T.C. (2004). Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks. *American Journal of Agricultural Economics* 86(2), 467-482

McFadden, D. (1974). Conditional Logit Analysis of Qualitative Choice Behavior. In P. Zarembka (eds.), *Frontiers in Econometrics.* New York, US: Academic Press.

Michaud, C., Llerena, D. & Joly, I. (2013). Willingness to pay for environmental attributes of non-food agricultural products: a real choice experiment. *European Review of Agricultural Economics* 40(2), 313-329.

Murray, A.G. & Mills, B.F. (2011). Read the Label! Energy Star appliance label awareness and uptake among U.S. consumers. *Energy Economics* 33(6), 1103-1110.

Upham, P., Dendler, L., & Bleda, M. (2011). Carbon labeling of grocery products: Public perceptions and potential emissions reductions. *Journal of Cleaner Production*. 19, 348-355

Quinn, I. (2012) ‘Frustrated’ Tesco ditches eco-labels. *The Grover*. Available at: http://www.thegrocer.co.uk/companies/supermarkets/tesco/frustrated-tesco-ditches-eco-labels/225502.article?utm_medium=email&utm_source=groceronline%40wrbm.com&utm_campaign=1145974_Daily+30%2f1%2f12&utm_content=Frustrated-Tesco-ditches-eco-labels&dm_i=131K,OK8M,5DVZ23,1ZDEY,1. Accessed on: Mar. 21. 2014.

Vitousek, P.M. (1994). Beyond Global Warning: Ecology and Global Change. *Ecology*, 75(7), 1861-1876.

Appendix, Profiles of hypothetical apples

	Apple 1			Apple 2		
Block	Grade	Carbon	Price	Grade	Carbon	Price
1	Good	No carbon labeling	$44	Good	LCPC	$18
1	Superior	LCPC	$35	Marketable quality	LCPC	$26
1	Marketable quality	MLCC	$26	Good	MLCC	$44
1	Superior	No carbon labeling	$18	Superior	CEC	$35
1	Good	No carbon labeling	$35	Good	MLCC	$18
1	Superior	MLCC	$18	Marketable quality	No carbon labeling	$18
2	Good	LCPC	$35	Marketable quality	MLCC	$35
2	Superior	CEC	$18	Good	LCPC	$44
2	Marketable quality	LCPC	$18	Superior	No carbon labeling	$18
2	Marketable quality	MLCC	$35	Superior	CEC	$26
2	Good	No carbon labeling	$44	Superior	CEC	$44
2	Superior	No carbon labeling	$26	Good	No carbon labeling	$26
3	Marketable quality	LCPC	$44	Good	No carbon labeling	$44
3	Marketable quality	CEC	$35	Good	CEC	$18
3	Marketable quality	No carbon labeling	$18	Marketable quality	MLCC	$26
3	Superior	CEC	$44	Superior	MLCC	$35
3	Good	MLCC	$26	Marketable quality	LCPC	$18
3	Good	MLCC	$26	Superior	LCPC	$35
4	Superior	MLCC	$44	Good	MLCC	$26
4	Marketable quality	CEC	$44	Superior	LCPC	$26
4	Marketable quality	No carbon labeling	$35	Marketable quality	CEC	$44
4	Superior	LCPC	$26	Good	CEC	$35
4	Good	CEC	$18	Marketable quality	No carbon labeling	$44
4	Good	LCPC	$26	Superior	No carbon labeling	$26
5	Marketable quality	LCPC	$18	Good	LCPC	$35
5	Superior	CEC	$26	Marketable quality	CEC	$44
5	Marketable quality	MLCC	$44	Marketable quality	No carbon labeling	$35
5	Good	LCPC	$18	Superior	MLCC	$44
5	Good	CEC	$44	Marketable quality	CEC	$26
5	Superior	No carbon labeling	$35	Superior	No carbon labeling	$18
6	Superior	MLCC	$35	Superior	LCPC	$44
6	Good	MLCC	$18	Good	CEC	$26
6	Marketable quality	No carbon labeling	$26	Marketable quality	LCPC	$35
6	Superior	LCPC	$44	Marketable quality	CEC	$18
6	Good	CEC	$35	Good	No carbon labeling	$35
6	Marketable quality	CEC	$26	Superior	MLCC	$18