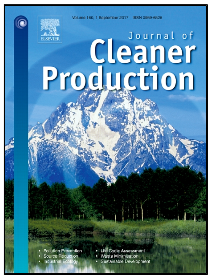
Accepted Manuscript



Increasing the Influence of CO_2 Emissions Information on Car Purchase

Ricardo A. Daziano, E.O.D. Waygood, Zachary Patterson, Markéta Braun Kohlová

PII:	S0959-6526(17)31422-1
DOI:	10.1016/j.jclepro.2017.07.001
Reference:	JCLP 10003
To appear in:	*Journal of Cleaner Production*
Received Date:	09 February 2017
Revised Date:	16 May 2017
Accepted Date:	01 July 2017

Please cite this article as: Ricardo A. Daziano, E.O.D. Waygood, Zachary Patterson, Markéta Braun Kohlová, Increasing the Influence of CO_2 Emissions Information on Car Purchase, *Journal of Cleaner Production* (2017), doi: 10.1016/j.jclepro.2017.07.001

Increasing the Influence of CO_2 Emissions Information on Car Purchase

Ricardo A. Daziano
Associate Professor
School of Civil and Environmental Engineering
220 Hollister Hall
Ithaca, NY 14853, USA
Phone: (607)-255-2018
Fax: (607) 255-9004
daziano@cornell.edu

EOD Waygood
Assistant Professor
Graduate School of Urban and Regional Planning (ÉSAD)
Université Laval
2325 des Bibliothéques street
FAS-1622
Quebec (QC) G1V0A6
Canada
Phone: (418) 656-2131 x.3740
Fax: (418) 656-2018
owen.waygood@esad.ulaval.ca

Zachary Patterson
Associate Professor
Department of Geography, Planning and Environment
Concordia University
1455, blvd. De Maisonneuve ouest
Montreal (QC) H3G 1M8
Canada
Phone: (514) 848-2424
zachary.patterson@concordia.ca

Markéta Braun Kohlová
Senior Researcher
Charles University Environment Center
José Martího 2/407
Prague 6, 162 00
Czech Republic
Phone: (420) 220 199 466
marketa.braun.kohlova@czp.cuni.cz

ABSTRACT

In response to concerns related to climate change, and an attempt to encourage more sustainable behavior, individuals are often provided with information on greenhouse gas emissions (GHGs) of consumer items, such as personal vehicles. Currently in the US, information on vehicle efficiency is provided as grams of carbon dioxide (CO_2) per mile. Previous research presenting CO_2 as a mass and testing willingness-to-pay through Discrete Choice Experiment has found that such information can influence vehicle choice. However, other research has questioned whether *how* this information is presented might affect choice. That research argues that CO_2 emission information generally lacks contextualization that allows for interpretation. As well, it argues that the type of contextualization may affect choices. That research though did not test willingness-to-pay and the strength of its influence is not clear. In addition, research exists that argues that using pro-social, as opposed to financial, contextualization might be more influential on people's choices. Thus, the purpose of this paper is to build on these previous findings on how CO_2 emissions are presented to determine whether changing *how* that information impacts vehicle choice with a Discrete Choice Experiment of vehicle choice analyzed using latent class modeling. No previous study has so robustly studied the influence that different framings might have on vehicle purchase. Five different methods of presenting CO_2 information are tested in this experiment: CO_2 emissions as grams per mile (current method), CO_2 emissions as pounds per year (consistent imperial units), CO_2 emissions as tons per year (yearly contextualization), an annual tax on CO_2 (yearly financial contextualization), and CO_2 as a percentage of the 2025 US EPA reduction target of 26% from 2005 levels (social goal contextualization). Results demonstrate that the current method results in lowest willingness to pay for CO_2 emission reductions, while the social goal contextualization results in the highest.

1. INTRODUCTION

In response to climate change concerns, as well as attempts to encourage more sustainable behavior, individuals are often provided with information on greenhouse gas emissions (GHGs) of things they buy, such as personal vehicles. Currently in the United States (US), such information is provided through the US Environmental Protection Agency's (EPA) information sheet for new vehicles. On these sheets, CO_2 emissions are expressed as grams of carbon dioxide (CO_2) per mile. Previous research has found such information can influence vehicle choice, but it has also found that it might depend on the type of person with some individuals being highly influence, while others not at all. Further, other research has also questioned whether *how* this information is presented might affect choice. That research found that how the information is presented influences whether people who are not motivated by climate change concerns would be influenced. Thus, there is a suggestion that providing CO_2 information as a mass (as the US EPA does) would only influence people who are highly motivated by environmental concerns, while another set of research suggests that is likely a problem of how the emissions information is presented. The purpose of this paper is to build on these previous findings to determine whether changing *how* CO_2 information impacts vehicle choice and Willingness-to-Pay (WTP) for CO_2 emission reductions. One key contribution would be whether it is possible to influence those less concerned by climate climate change. The use of Discrete Choice Experiments allows us to create controlled treatments of how information about emissions is presented. Analyzing the results through latent class discrete choice models allows for a segmentation of the population by their response strengths. This allows us to test whether the information is influencing all groups, or just the more environmentally motivated ones. One specific contribution in the application of the discrete choice models is the explicit consideration of discounting not only future costs but also future emission production. The next section provides background relevant to the study and is followed by a section describing the methodology adopted to answer the question. Results are then presented and discussed and the paper finished with some concluding remarks.

1.1 Background

One reason to provide information to people is so they can make more informed choices. As well, businesses provide information on their products, whether rational or emotional, in order to persuade consumers to choose their products. The government, on the other hand, may take a soft paternalism approach where information is given so that an individual makes choices that are in the individual's (or society's) best interest. For example, the provision of information about health risks from smoking is often provided directly on tobacco products.

Another frequent approach to influencing choice is through economic means by raising the price of products through taxes or other measures. This method does not require that people be concerned about the problem, since the impact is on their personal budget. However, the impact of such methods depends on an individual's income (the impact will be relative) and is only as effective as the amount of the tax. In many cases, it is politically difficult to implement taxes of any kind, let alone one those explicitly intended to coax certain types of behavior.

People are accustomed to understanding product attributes such as cost. However, it is difficult for people to judge the meaning of CO_2 emissions. Providing only grams of CO_2 per mile might be likened to providing the amount of salt in a product, but with no additional information such as the percentage of recommended daily consumption to avoid health problems. A heavy burden of knowledge is placed on the consumer to know what the limits are, what average consumption of the product might be, and then to undertake the calculations to estimate whether the amount exceeds that threshold. In such a situation, one might first question whether providing CO_2 emission information has any impact on choice at all.

Previous stated-choice research related to vehicle purchase and use has found that providing CO_2 information will affect choices. In a series of experiments, Gaker et al. (2010, 2011, 2013) demonstrated that for populations of students (Gaker et al., 2011; Gaker et al., 2010) and a sample of San Francisco residents (Gaker and Walker, 2013), providing CO_2 information as tons per year (car purchase) or grams per mile (route choice) has a measurable impact. In Germany (Achtnicht, 2012; Daziano and Achtnicht, 2014) studies have also found that providing CO_2 information (grams per kilometer) would have an influence on car purchase choice. Thus, there is evidence that such information could influence choice, but other research has questioned whether this format (CO_2 as a mass) is an effective means of communicating emissions.

Research into how CO_2 information is provided to the general public has generally found that it leaves many people uncertain. Research examining online GHG calculators (a tool where individuals estimate their GHG emissions) has highlighted that presenting CO_2 as a mass (e.g. grams, pounds, tons) leaves people uncertain about whether the amount is acceptable or not (Chatterton et al., 2009; Coulter et al., 2007). The problem may be related to context (Avineri and Waygood, 2010; Waygood and Avineri, 2010a, b; Waygood and Avineri, 2011, 2013; Waygood and Avineri, 2014, 2016a; Waygood and Avineri, 2016b). As argued by Waygood and Avineri (2011), people lack a budget or other means of interpreting the GHG information, thus their perception of the amount is highly influenced by contextual information, such as the other choices provided, the standard by which the amount is measured (Waygood and Avineri, 2011, 2013; Waygood and Avineri, 2016b), or even the wording (Avineri and Waygood, 2013).

Whether providing people with only CO_2 mass information would influence their choices may relate to how environmentally motivated they are. Waygood and Avineri (2011, 2016b) found that people who were further along the climate change "stage of change process" (i.e. they accepted that climate change was a problem and had made or were considering making changes to reduce their impacts) were more likely to feel that they understood information on CO_2 mass. In Gaker et al.'s research using latent class models (2013), they found that a group of environmentalists (with "big hearts") were influenced by the CO_2 grams per mile, whereas the non-environmentalists were not; the problem being that most individuals were classified as the latter group. Thus, the problem may be that providing simply CO_2 mass may require an individual to be environmentally motivated (Avineri and Waygood, 2010; Gaker and Walker, 2013; Waygood and Avineri, 2011; Waygood and Avineri, 2016b) in order for it to influence their behavior. In such a way, the effect of the information on CO_2 emissions is moderated by environmental concerns, and if those do not exist or have little value to the individual, the information is not taken into account.

One source of difficulty in interpreting CO_2 information in grams per mile might be related to how CO_2 is discussed in the general media. Although vehicle advertisements may use grams per mile or km, reports on climate change from governments and organizations are likely to use tons (or ton) per year (e.g. http://data.worldbank.org/indicator/EN.ATM.CO2E.PC or http://unstats.un.org/unsd/environment/air_co2_emissions.htm). It may be that simply contextualizing the information to an estimated yearly impact would increase the effectiveness of such information on vehicle choice. The EPA currently does this with fuel efficiency by estimating yearly savings. This would reduce the mental burden on the individual. With a yearly contextualization, the individual does not have to conduct the mental math to go from grams per mile (metric unit of mass and imperial units of distance) to tons per year (imperial unit of mass and unit of time).

The current car label system from the Environmental Protection Agency contextualizes vehicles on a sliding scale from 1 to 10 (10 being best). However, this contextualization is with respect to other vehicles, not with respect to total emissions. Without a clear understanding of the impact of those different levels, one could not make an informed decision. It would be analogous to making a decision on how much to spend each month without knowing what your financial budget was.

Considering several different methods of presenting the same information, contextualizing the information with respect to a cap or threshold may be the most effective in terms of respondents being confident in ranking information or by the likelihood of a behavioral response (e.g. would they consider changing their travel behavior) (Waygood and Avineri, 2011, 2013, 2014, 2016b). Such contextualization provides an interpretation of the amount with respect to an authority's evaluation of what is acceptable or not. This could be a respected non-governmental environmental group, or a government objective for diminishing such emissions. In either case, such a method of presenting the information could be considered an injunctive norm (e.g. Cialdini, 2007), as it would communicate to an individual whether the choice is acceptable or approved by society. As such, this method would not necessarily rely on how environmentally motivated an individual was, but simply whether they value "doing the right thing" in terms of society's goals.

Another argument related to contextualizing information is to let the market influence decisions by monetizing negative externalities. A value is determined related to the negative impact of a choice (here, the negative impact of GHGs), and this is included in the cost. In Canada, the province of British Columbia (BC) has since 2008 used a carbon tax as a means to contextualize and give feedback to individuals related to their consumer choices. The policy has been judged to be successful in reducing GHGs (Prosperity, 2012; Rivers and Schaufele, 2015). In fact, Rivers and Schaufele (2015) demonstrated that the behavioral response to the BC carbon tax was 7.1 times larger than what would be expected from an equivalent change in the carbon tax-exclusive gasoline price. In the US, the EPA provides information on how much a ton of CO_2 should be valued. With such information, an individual's personal economic considerations would be triggered. Thus, this is one potential way of influencing choices.

Arguments exist that people's behavior is not always stronger when given economic signals. Monetary rewards are found to depend on the magnitude of compensation, whereas social market signals are not (Heyman and Ariely, 2004). Avineri (2012) argues that people are often motivated to "do the right thing," meaning that they wish to behave in a way that society approves. This relates to theories such as the norm-activation theory (Schwartz, 1977) where people would be made aware of their moral obligation to conduct behavior where the benefit is not, or not solely, individual. Further, considering that climate change is a societal as opposed to an individual problem (i.e. the impacts are on all of society irrespective of individual behavior), it may be that information contextualized at a societal level may be more effective than information that is ego-centric (i.e. an individual impact). This would relate to a moral responsibility to behave in a certain way, which is found to be effective in explaining ecological behavior (Kaiser and Shimoda, 1999), including predicting an intention to reduce car use in response to a proposed environmental transportation policy (De Groot et al., 2008).

Thus, previous research suggests that CO_2 information can influence choice, but that its influence depends on individual environmental attitudes and how it is presented. Previous research on willingness to pay (Achtnicht, 2012; Daziano and Achtnicht, 2014; Gaker et al., 2011; Gaker and Walker, 2013; Gaker et al., 2010) has only used grams of CO_2 per distance, whereas previous research on how the CO_2 information is presented (Avineri and Waygood, 2013; Waygood and Avineri, 2011, 2013; Waygood and Avineri, 2014, 2016a) used ranking exercises and behavioral responses (e.g. changes in travel behavior) with relatively small samples (<300) to demonstrate how different presentation modes of CO_2 can affect people's stated responses. Thus, it remains to be seen whether in Discrete Choice Experiments, such differences can be observed, to what extent they differ, and how much of an influence a respondent's environmental attitudes may have on the outcomes.

This research will therefore test two hypotheses:

1) Presenting CO_2 emissions information as grams/mile will result in the lowest willingness to pay;

2) Controlling for environmental attitudes, how CO_2 emissions information is provided will not affect willingness to pay.

2. METHODOLOGY

In order to evaluate the effect of presentational form of CO_2 information and environmental attitudes on WTP, a survey containing two distinct parts was used. The survey was administered as an online survey to a panel of 1,580 car owners living in Philadelphia and Boston metropolitan areas between 15 December 2015 and 15 March 2016. The Discrete Choice Experiment on vehicle choice is explained in detail below. The other part of the survey focused on the socio-demographics and environmental attitudes of respondents.

2.1 Sociodemographics and Environmental Attitudes of Respondents

General socio-demographic information along with some questions related to tax policy preferences in the context of climate change are shown in Table 1. Whereas questions related to car ownership were asked before the discrete choice experiment, questions related to the environment were asked after so as not to influence the individual's choices in the choice tasks by priming respondent environmental awareness or identity. Questions on environmental attitudes and tax policy preferences in the context of climate change included:

- 50 questions that were a version of the General Ecological Behavior (GEB) scale (Kaiser and Wilson, 2004);
- 15 questions on pro-ecological worldview of the New Ecological Paradigm (NEP) scale (Dunlap et al., 2000);
- Four questions of tax policy preferences to GHGs (Leiserowitz, 2006): (see Table 2 for complete questions).

TABLE 1 Selected results for respondent characteristics

TABLE 2 Responses to questions addressing climate change.

Lachapelle et al. (2012) report that support for a cap-and-trade system for carbon emissions is opposed by 49% of Americans, and this opposition rises to 74% when the amount is \$50/tonne[1]. For a carbon tax, 62% oppose the concept and this rises to 63% for \$15/tonne and 80% for \$50/tonne. Our sample also mostly opposes general increases such as question 2 (66% oppose)

[1] One metric tonne (long ton) is roughly equal to 1.1 "short" tons.

and 4 (61% oppose) in Table 2. A large number do not want to pay for emitting (question 1, 45%), and of those willing to pay, nearly half are only willing to pay \$5/ton. At \$50/tonne (roughly \$55/ton) 94% of our sample are not willing-to-pay.

A number of national (USA) poles exist with respect to climate change and public opinion. The questions asked are not an exact match to the questions used in this study, however the information is comparable. The Gallup Poll question "How much do you personally worry about Global Warming?" resulted in (2014): A great deal, 34%; fair amount, 22%, only a little/not at all, 43%. If one considers question 5 in Table 2, those who are sufficiently concerned to want to reduce, or have reduced, their emissions, this represents 56% of the population which coincides with the 56% of the national population who personally worry a great deal or a fair amount.

To account for *general ecological behavior*, questions from the GEB scale were included. This scale is based on a theory of goal-directed behavior (Kaiser and Wilson, 2004), the framework that describes a person's general attitude in terms of the likelihoods of engaging in various specific environmentally-friendly behaviors. The GEB questions (50 in total) relate to conservation behaviors in six domains: energy conservation (11), mobility and transportation (12), waste avoidance (5), consumerism (9), recycling (4), and vicarious social behaviors (9). The transportation questions were separated out so that general environmental behavior and transport-specific conservation behavior factors could be estimated. A principal component analysis (PCA) was conducted on the participants' responses to those 38 questions (i.e. the 50 GEB questions minus the 12 mobility and transportation questions). The initial PCA found that a large number of those 38 variables did not have a large explanatory role (shown as communalities less than 0.3) in differentiating individuals. Thus 15 variables were retained and used in a second round of principal component analysis. A two-factor solution (Table 2) was identified using Oblimin rotation and Kaiser normalization that accounted for 41.3% of the variation. Those two factors were named: "actively environmental," and "not interested in solar panels."

TABLE 3 High loading variables for each principal component of the factor analysis on general ecological behavior and tax policy preferences variables.

For *transportation behavior*, the 11 variables from the GEB scale were used along with questions on household car ownership, average mileage, and how often they commute by car. One question from the GEB scale was adjusted from their *mobility and transportation* domain, "In nearby areas (around 30 km; around 20 miles), I use public transportation or ride a bike" was changed to two separate questions: "In nearby areas (around 5 miles), I ride a bike;" and "For distances up to 20 miles, I use public transportation." Of the 15 available variables (11 + 1 from GEB, and the three general transportation questions), fourteen were retained for the principal component analysis. A four-factor solution was found using Oblimin rotation and Kaiser normalization that explained 52.4% of the variation. Those factors were named: multi-modal, drives everywhere, idles, and rules (e.g. speed limit) over economics (e.g. drive to conserve fuel).

To account for *personal ecological values and beliefs*, the NEP scale was used. It represents a more evaluative conception of attitudes assuming one's moral values to be the core concept of environmental attitudes (Dunlap et al., 2000). As well, four additional questions on tax policy preferences in the context of climate change were included (*36*), as the NEP scale does not directly target climate change. From a potential of 19 questions on attitudes towards the environment (15 from NEP and 4 directly related to transportation and climate change), 18 were used in a principal component analysis with Oblimin rotation and Kaiser normalization. Two factors were identified which accounted for 50.4% of the variation. Those factors were named: "against taxes to reduce emissions"; and "nature will not sort out environmental problems".

2.2 Discrete Choice Experiment

The survey involved a Discrete Choice Experiment prior to the questions on ecological behavior and environmental attitudes. Discrete Choice Experiments (DCE) are specialized surveys that present respondents with hypothetical choice situations (or tasks). The characteristics (or attributes) of the alternatives are determined through an experimental design. Respondents are asked to choose their preferred alternative. The statistical analysis of these responses allows an estimation of the impact of the different attributes on a person's choice.

For this study, a very simple DCE was used whose focus was to enable the estimation of WTP for CO_2 reductions. In order to be consistent with previous DCE research on WTP for CO_2 reductions, we adapted vehicle choice surveys first done by Gaker et al. (2010, 2011). The choice tasks in the surveys had two alternative vehicles characterized by two to three attributes. The attributes included were purchase cost, fuel costs per year and CO_2 emissions. The vehicle choice experiment was designed according to a D-efficient design with Bayesian priors. The design was produced using Ngene. For the priors, estimates from the literature were used for the pilot of the experiment. The design was then updated with the estimates of the first 150 observations. The attributes and the levels used in the experiments are summarized in Table 4. Purchase price was customized to the respondent's stated willingness to spend for their next vehicle. This was done to eliminate the problem of unrealistic choices being presented to respondents, or choices being dominated by price.

In order to test the influence of the different presentational forms, the participants were randomly assigned to one of five treatments: CO_2 emissions as grams per mile, CO_2 emissions as pounds per year, CO_2 emissions as tons per year, an annual tax ($37/ton) on CO_2, and CO_2 as a percentage of the 2025 US EPA reduction target of 27% from 2005 levels. 27% was used as the average between 26% and 28% given as the government targets.[2] Following the current car-label standard, for all treatments, 15,000 miles/year was used to calculate annual amounts.

To explain further the last treatment (target reduction), the amount used was based on 5.15 ton as the average per-capita road transport emissions in 2005. That number is based on per-capita CO_2 road emissions (ITF data) in 2005, and is thus a conservative amount as it includes more than just private light duty vehicles. Thus, a 27% reduction results in 3.75 ton/year in 2025[3].

[2] www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change

[3] For information, the US Department of Energy estimates that the per capita fuel consumption in 2005 was 461 gallons which is the equivalent of 4.1 tons (using the EPA guidelines of 8,886 g CO_2/gallon).[3] Using that amount would have resulted in a target of 3 ton/year in 2025, thus increasing the percentages presented, which one assumes would have increased the strength of responses. These results would have been different had we used vehicles as opposed to the population in the calculation of average annual CO_2 production, since in the US there were 811 vehicles per 1,000 people (in 2005). This would have increased the starting amount to 6.34 ton. However, if one uses the fuel consumed by LDV only, then one arrives at 5.06 ton, which is roughly the original 5.15 ton. Next, using vehicles as opposed to the population would imply that those who buy vehicles are allowed to pollute more than those who don't, which is not an equitable approach. Finally, if one were to take population growth into account, the reduction

TABLE 4 Experiment attributes and levels

Table 4 shows the attributes and their levels used in the experiment. Whereas these attribute levels reflect realistic values of actual vehicle characteristics, real-world correlation between fuel cost and emissions was not considered in order to ensure orthogonality of the experimental design. In addition, emission information treatments (those listed above) were constructed using relevant equivalencies depending on the treatment. The design resulted in 12 choice tasks per individual. The order of the choice situations was randomized in the online survey, as was the CO_2 presentation treatment that a respondent received. The exact wording of the choice questions is shown in Figure 1.

Figure 1. Example of choice experiment question.

2.3 Structural model

To analyze choices made by individuals in response to the vehicle choice experiment, we assume that respondents acted as utility maximizers and that utility is a function of the present value of the monetary and monetized vehicle attributes. Since personal vehicles are durable goods that are owned and used over a time horizon, utility of individual i, when choosing alternative j is specified as follows:

$$U_{ij} = \alpha\left[P_{ij} + PVFC_{ij} + PVFE_{ij}\right] + \varepsilon_{ij}, \quad (1)$$

where PVFC is the present value of the future (operating costs) over the holding horizon, PVFE is the present value of the (monetized) future emissions, and $-\alpha$ is the parameter that represents the marginal utility of income. We note that previous work (Achtnicht, 2012; Daziano and Achtnicht, 2014; Gaker et al., 2011; Gaker and Walker, 2013; Gaker et al., 2010) has not introduced discounting, failing to recognize emission production and costs over the ownership horizon.

If both emissions and operating costs are measured on a *per-month* basis, then:

$$PVFC_{ij} = \sum_{t=1}^{L_{ij}} \frac{1}{(1+r_i)^t}\mathbb{E}(C_{ijt}), \; PVFE_{ij} = \omega_{E,i}\sum_{t=1}^{L_{ij}} \frac{1}{(1+r_i)^t}\mathbb{E}(E_{ijt}), \quad (3,4)$$

---

target amount should be further reduced. Thus, overall we suggest that the simple approach taken to estimate the starting per capita average CO_2 emissions is conservative and follows an equitable approach.

where r_i is the monthly subjective discount rate (reflecting time preferences of the individual), L_{ij} is the total number of months of ownership, $\mathbb{E}(C_{ijt})$ is the expected value of operating costs in month t, $\mathbb{E}(E_{ijt})$ is the expected value of the emissions per period, and ω_{E} is the marginal willingness to pay for reducing emissions (over the whole ownership horizon, i.e. willingness to pay for reducing one unit of emissions over the whole period in which the car is owned). If oc_i is the monthly uniform equivalent of future operating costs, and emissions$_i$ is the monthly uniform equivalent of the future emissions, and if the number of months of ownership is large, then:

$$PVFC_{ij} = \frac{C_{ij}}{r_i},\ PVFE_{ij} = \omega_{E,i}\frac{E_{ij}}{r_i}, \qquad (5,6)$$

meaning that, using the capitalized cost approximation, it is possible to rewrite the choice model as:

$$U_{ij} = \alpha\left[P_{ij} + \frac{C_{ij}}{r_i} + \frac{\omega_{E,i}}{r_i}E_{ij}\right] + \varepsilon_{ij}, \qquad (7)$$

where r_i becomes an additional parameter to estimate.

Two different discrete choice model formulations were used: a base Multinomial Logit, and a Latent Class Logit. The two discrete choice model formulations are tested to ensure that differences in WTP are not the result of not having allowed for the relaxation of the strong assumptions of the Multinomial Logit Model.

Each model was constructed to test the hypothesis that the way in which emission information is presented has an impact on estimates of willingness to pay to reduce emissions. Since the structural model requires a monthly basis, all time-dependent attributes were transformed to units per month. In addition, tons per month was considered as the reference (because dollars per ton is a relatively standard unit for emission abatement). In the case of grams per mile, the stated mileage by the respondent was used to calculate the tons per month equivalent.

The base model was then specified with the use of an indicator variable for how the emission information was presented, using tons (T_i) as baseline :

$$U_{ij} = \alpha P_{ij} + \frac{\alpha}{r}\left[C_{ij} + \tau_{ij}D_{tax} + (\omega_{tons} + \delta_{gpm}D_{gpm} + \delta_{ppm}D_{ppm} + \delta_{obj}D_{obj})T_i\right] + \varepsilon_{ij}, \qquad (8)$$

The $D_{.}$ variables are a series of binary variables indicating the treatment used to convey the emission information. D_{tax} is thus an indicator variable that equals 1 when the information was presented as a tax, D_{gpm} indicates that the information was presented in grams per mile, D_{ppm} in pounds per month, and D_{obj} as a target objective. An additional parameter for the tax t_{ij} was considered to see if there were any additional impact of their simply being a tax ($\tau_{ij}D_{tax} + \delta_{tax}\tau_{ij} D_{tax}$), but the additional parameter (δ_{tax}) was not statistically different from zero in all specifications. Note that all parameters in the base model are assumed fixed.

3. RESULTS

Based on the structural model above, the following section presents estimates of subjective discount rates and willingness to pay for CO_2 emission reductions for each of the presentational formats, as described above. The Multinomial Logit results are presented first, followed by those of the Latent Class Logit.

Before presenting the WTP results, we first mention that the results for the carbon tax treatment (not presented here) demonstrated that our respondents performed logically according to financial influences. That is, respondents were willing to pay one dollar to save one dollar. Thus, using a tax to influence choice depends solely on the size of the tax. The social cost of carbon used in this study was \$37/ton, which was based on the EPA's "Fact Sheet: Social Cost of Carbon" (EPA, 2013). Thus, we found that charging individuals \$37/ton of CO_2 resulted in a WTP of roughly \$37/ton.

3.1 WTP Estimates with the MNL Formulation

The subjective discount rates and WTP for CO_2 emission reductions, both estimated with the base Multinomial Logit Model, can be found in Table 5. Subjective discount rates are presented by month and by year. The models were estimated simply as a function of price and operating cost. Two MNL specifications were formulated, MNL-1 with only one subjective discount rate and MNL-2 with a different discount rate for the treatment without emission information. The hypothesis for MNL-2 is that individuals value operating cost differently when emission information is omitted.

TABLE 5 Estimated WTP with Multinomial Logit Specification

The subjective discount rate estimated with the MNL-1 specification was 1.02% on a monthly basis, and 13.00% on an annual basis. Compared with typical automotive market interest rates (that reflect cost of capital) (Allcott and Wozny, 2014), the subjective discount estimate of 13% is high. At the same time, it is well within the bounds of estimates that have been found in many different discrete choice studies of vehicle choice (Wang and Daziano, 2015). In fact, estimates were found ranging from 9.6% to 47% derived from 20 studies between 1980 and 2012. For the MNL-2 specification, the annual discount rate for the individuals who received emission information is slightly higher at 13.90%, whereas that for the group that didn't receive emission information was estimated at 10.52%. When emissions are omitted, individuals may be more attentive to operating costs and act in a more forward-looking manner (while still exhibiting somewhat myopic behavior as the discount rate still is higher than market interest rates.) In terms of the Bayesian Information Criterion (BIC), MNL-2 is preferred to MNL-1.

With respect to MNL-2 estimates of WTP for CO_2 reductions, Table 5 can be interpreted this way: ω_{tons} is the WTP of the base case (tons per year framing) and the δ parameters refer to the differences from the base case. The statistical significance of ω_{tons} means that its influence is statistically significantly different from zero (0). The combined results of ω_{tons} and the δ parameters may result in a non-significant result. The meaning of such a result is that the total influence is not statistically different from zero (0).

When CO_2 information (CO_2EI) was presented as tons per year (the base case), respondents were willing to pay \$277.25 (¢13.86) to reduce CO_2 emissions by one ton. To interpret the other estimates, it is necessary to recognize they are incremental with respect to the base WTP of tons per year (ω_{tons}). This specification allows us to test directly whether variation in the willingness to pay under the different presentational modes is significant or not (statistical significance for the WTP variants are based on the δ parameters).

When CO_2EI was presented to respondents as pounds per month, the result of \$243.22 (¢12.16) per ton (pound) was found, which is statistically different from zero. However, the difference (δ) is not statistically different from the base case (ω_{tons}). Thus, there appears to be some advantage to presenting the information on a yearly as opposed to monthly amount, though this difference is not statistically significant.

Providing CO_2EI in the form of a societal objective was the most influential. The WTP estimate was much larger, and statistically significantly different (δ), with a value of \$371.31 (¢18.57) per ton (pound).

Presenting CO_2EI as grams per mile was not statistically different from zero at \$28.63/ton, though it was statistically different from the base case (δ_{gpm} = -248.62). Thus, the first hypothesis is confirmed: presenting CO_2EI as grams per mile is the least influential framing.

3.2 WTP Estimates with the Latent Class Formulation

The multinomial logit model, has some important limitations. Although it can capture preferences that vary systematically with respect to observed characteristics of decision makers (e.g. gender), it is not capable of capturing preferences that vary with unobserved characteristics. As a result, it is increasingly common to use "Latent Class" models (Greene and Hensher, 2003). When such models are estimated, latent classes (or categories) of respondents are identified with a "class membership" model and different logit models are estimated for the members of each of the classes. In order to ensure that the results in our logit model were not caused by aggregating all respondents into one class, a Latent Class model was estimated, which is presented in Table 6. The model was estimated with the package *gmnl* in R (Sarrias and Daziano, 2016). After testing specifications with different numbers of classes, the best model (in terms of goodness of fit, statistical significance of variables, parameter magnitude, and BIC) was one with two classes. The class membership model included eight different variables resulting from the preceding factor analysis on environmental attitudes, general environmental behavior, and travel behavior indicators. As in the MNL case, two specifications were formulated. Whereas LC-1 assumes the same evaluation of costs for all treatments, LC-2 introduces a differing valuation for those individuals under the treatment without emission information. LC-2 is preferred to LC-1 in terms of BIC. McFadden's ρ^2 index of fit is 0.29 for model LC-2.

TABLE 6 Estimated WTP with 2 Latent Classes and Attitudinal Factors for Class Assignment

The results of the LCL-2 model can be interpreted in the same manner as the MNL model above in that the base case (ω_{tons}) was the tons per year framing, the δ parameters refer to (statistical) differences from the base case, and the combined WTP of ω_{tons} and δ are interpreted with respect to zero.

Before discussing the WTP results, the two classes are described. The latent class model (Table 6) indicates a discrete distribution in which some people (class 1) are more influenced by CO_2 emissions information. Note that in terms of subjective discounting, individuals in class 1 (49.98% of the sample population) use market interest rates (6.29%) for moving future costs and benefits to the present (and are forward looking when no emission information is provided, with a discount rate of 2.49%). Class 2 (50.02% of the sample population), with the lower overall willingness to pay for reducing emissions, aggregates individuals that exhibit myopic behavior in terms of discounting the future (with a 21.99% discount rate when emission information is provided; when CO_2 information is omitted, the discount rate is 9.94%, which still is somewhat higher than market interest rates).

As per assignment to the classes, the evidence suggests that several types of environmental attitudes and current behavior impact stated WTP to reduce car use emissions. Assignment to Class 2, which negatively affects WTP for all types of CO_2 emissions information, is consistent with what one might expect. Those individuals are 1.2 times (or 20%) more likely to be against taxes to reduce emissions, 1.3 times more likely to believe that nature will sort out environmental problems, 1.3 times (or 30%) less likely to be actively environmental, 1.1 times less likely to be interested in solar panels, 1.04 times less likely to be multi-modal, and 1.2 times more likely to follow road rules as opposed to trying to drive economically.

Thus, the model finds that people in class 1 are more likely to: be in favor of taxes to reduce emissions, have actively environmental behavior, and think that nature will *not* sort out environmental problems. Based on the WTP results, class 1 individuals have a higher willingness to pay and are more forward looking (based on subjective discount rates).

In the preferred LCL-2 model, class 1 (49.98%) has a base WTP (ω_{tons}) of ¢15.66 per pound of CO_2, whereas class 2 (50.02%) has a base WTP of ¢9.69 per pound of CO_2. Both cases are statistically significantly different from zero. For both classes, the framing of pounds per month was also statistically different from zero, but not statistically different (δ_{ppm}) from the base case.

The results for the grams per mile framing differ. In both cases the difference (δ_{gpm}) is significant, but for class 2 individuals (less environmentally motivated), the WTP is not statistically different from zero. Thus, although statistically different from the base case (tonnes per year), presenting the CO_2 information does not statistically influence choices.

Finally, in both cases the largest WTP was observed for the social objective framing. Class 1 individuals were found to have a WTP of \$381.70/ton while those in Class 2 had a WTP of \$236.61/ton. However, for Class 2 the difference (δ_{obj} = 42.74) was not statistically different from zero. Thus, for Class 2 only the framing of grams per mile is statistically different than the base case of tons/year.

4. DISCUSSION

The WTP estimates found here are on the lower end of recent estimates in the same context. That is, estimating WTP for CO_2 emissions information (CO_2EI) when presented as grams per mile from discrete choice experiments of vehicle choice. First, taking the MNL-2 case (Table 5), the WTP for the case of presenting the information as grams per mile in our study, we find a value of only ¢1.43 per pound of CO_2 which is not statistically different from zero. In contrast, Achtnicht (2012) estimated a WTP of ¢22 per pound of CO_2 (€349 per tonne) from a survey of potential car buyers in Germany, and Daziano and Achtnicht (2014) estimated ¢21 per pound on the same dataset with different statistical analysis. We suggest a number of reasons for this large difference. In the German case, beyond using grams per kilometer to present the information, the data collection method was a computer-assisted personal interview, thus the individual gave an answer in a public place (e.g. a car dealership) to a person. This could create a strong tendency for socially desirable responses. In our experiment, the individuals were paid to complete an anonymous online survey, thus the likelihood of socially desirable responses should be lower. Second, the units grams and kilometers are both metric, whereas grams per mile is a mix of metric and imperial system which may lead to lower comprehension. Third, 74% of Germans feel that climate change is a very serious problem (Eurobarometer, 2009). In the US 26% of Americans worry a great deal about climate change (Jones and Saad, 2014; Saad and Jones, 2016). Thus, there are a number of different factors that might explain this large difference.

Except for class 1 individuals of the LCL-2 model, presenting CO_2EI as grams per mile was not statistically different from zero. This result reflects previous findings such as those by Gaker and Walker (Gaker and Walker, 2013) who also applied latent class modeling and found that one group was willing to pay, while another was not. That study used pounds per trip in a mode choice experiment. In other related research Waygood and Avineri have also found that contextualizations as mass are much less influential for people who are not as concerned about climate change (Waygood and Avineri, 2011; Waygood and Avineri, 2016b). In those experiments, tonnes per year were used to motivate changes in driving behavior.

When the information was presented as tons/year, a value of ¢13.86 per pound of CO_2 was calculated. In comparison, Gaker et al. found WTPs of ¢37 (2010) and ¢14 (2011) based on samples of students from the University of California, Berkeley. Thus, the results are very similar to the latter experiment (Gaker et al., 2011), though much lower than the first (Gaker et al., 2010). What is striking, from a within-experiment perspective, is how much smaller our WTP estimate is when CO_2 information was presented in grams per mile. It is in fact 2.4 times smaller than the estimate when information is provided in tons per year (the base) for the Latent Class 1, and 5.6 times smaller for the Latent class 2 (Table 6). It is worth repeating that grams per mile is the standard presentation of CO_2 information on EPA fuel economy and environment labels for new cars. So here, the simple act of contextualizing the emissions output to a monthly or yearly amount based on 15,000 miles driven per year had at least a 2.4 times increase on the influence of such information on car purchase choices. As this is the current practice for information such as fuel economy, it would now seem obvious that the emissions information should at least be contextualized in a similar fashion.

Another remarkable result is how much higher WTP is when CO_2 information is presented as a societal goal (3.0 times larger for class 1 and 6.9 times larger for class 2 than when using grams per mile). We present two arguments why this may be. As discussed in the background section, Waygood and Avineri (2011) argued that people lack a budget or other means of interpreting GHG information. Thus, their perception of the amount is highly influenced by contextual information, and presenting CO_2 emissions information with respect to some limit might help people interpret whether an amount is appropriate or not. The second argument is that people (in general) want to “do the right thing” and that presenting emissions information with respect to a government objective changes the motivation from economic to social, which authors such as Ariely (Ariely, 2008, 2010; Ariely et al., 2009; Heyman and Ariely, 2004) would argue can have a greater influence than financial ones when the financial motivation is low. Considering that the social cost of carbon estimated by the EPA ranges from $12 to $61 in 2015 (5% to 2.5% average discount rate), but that fuel costs for an average driver in the USA would be in the thousands of dollars, the relative financial influence might be too small to motivate individuals towards lowering their emissions to a societally desirable level.

The willingness to take on personal costs for the public benefit is most apparent when not contexualizing. This is demonstrated by the 73% difference for the WTP of grams per mile between the two classes in the LCL-2 model. When the information is better contextualized by monthly/yearly averages or by the societal goal that difference is reduced to 38% for all three frames. This demonstrates that contextualizing the information can not only improve overall willingness-to-pay, but also reduce the disparity in response strength between those who are more environmentally motivated (class 1) and those who are not.

5. CONCLUSION

Using multinomial logit analysis, it was demonstrated that the current means of presenting CO_2 emissions information (in grams per mile) results in estimated WTP to reduce CO_2 that is significantly lower than those with context, and not even statistically different from zero. Here, the contextualizations were: tons per year (9.6x more influential than grams per mile), pounds per month (8.5x), and as a percentage with respect to the government's reduction targets (13.0x). In contrast to previous such studies, the experiment participants were a general American car-owning population. This may explain the lower willingness to pay amounts observed with respect to grams per mile. The population performed rationally when a tax was used, since they were willing to pay one dollar to save one dollar (a social cost of carbon of $37/ton was used). However, although no additional cost was assigned to it, presenting the CO_2 emissions information with respect to the government's reduction targets resulted in a willingness to pay $371/ton. The clear implication for this is that more effective means exist for communicating with the public about the climate change emissions of their consumer choices than are currently being applied.

ACKNOWLEDGMENTS

This research is based upon work supported by the National Science Foundation Award No. CMMI-1462289. Pretests were supported by the Institute for the Social Sciences at Cornell University. The collaboration of Markéta Braun Kohlová on this research was funded by the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement number 609642.

REFERENCES

Achtnicht, M., 2012. German car buyers' willingness to pay to reduce CO2 emissions. Climatic Change 113, 679-697.

Allcott, H., Wozny, N., 2014. Gasoline prices, fuel economy, and the energy paradox. Review of Economics and Statistics 96, 779-795.

Ariely, D., 2008. Predictably Irrational. HarperCollins, New York, USA.

Ariely, D., 2010. The Upside of Irrationality: The Unexpected Benefits of Defying Logic at Work and at Home. Harper Collins, New York.

Ariely, D., Bracha, A., Meier, S., 2009. Doing good or doing well? Image motivation and monetary incentives in behaving prosocially. The American Economic Review, 544-555.

Avineri, E., 2012. On the use and potential of behavioural economics from the perspective of transport and climate change. Journal of Transport Geography 24, 512-521.

Avineri, E., Waygood, E.O.D., 2010. Behavioural Inception Report. Carbon Aware Travel Choices (CATCH).

Avineri, E., Waygood, E.O.D., 2013. Applying valence framing to enhance the effect of information on transport-related carbon dioxide emissions. Transportation Research Part A: Policy and Practice 48, 31-38.

Chatterton, T.J., Coulter, A., Musselwhite, C., Lyons, G., Clegg, S., 2009. Understanding how transport choices are affected by the environment and health: Views expressed in a study on the use of carbon calculators. Public health 123, e45-e49.

Cialdini, R.B., 2007. Descriptive social norms as underappreciated sources of social control. Psychometrika 72, 263-268.

Coulter, A., Clegg, S., Lyons, G., Chatterton, T., Musselwhite, C.B.A., 2007. Exploring public attitudes to personal carbon dioxide emission information. Department for Transport, London.

Daziano, R.A., Achtnicht, M., 2014. Accounting for uncertainty in willingness to pay for environmental benefits. Energy Economics 44, 166-177.

De Groot, J.I., Steg, L., Dicke, M., 2008. Transportation trends from a moral perspective: Value orientations, norms and reducing car use. New transportation research progress, 67-91.

Dunlap, R.E., Van Liere, K.D., Mertig, A.G., Jones, R.E., 2000. New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. Journal of social issues 56, 425-442.

Environmental Protection Agency (EPA), 2013. Fact Sheet: Social Cost of Carbon, in: Agency, E.P. (Ed.). Environmental Protection Agency, epa.gov.

Eurobarometer, S., 2009. Europeans' attitudes towards climate change. European Commission.

Gaker, D., Vautin, D., Vij, A., Walker, J.L., 2011. The power and value of green in promoting sustainable transport behavior. Environmental Research Letters 6, 034010.

Gaker, D., Walker, J.L., 2013. Revealing the Value of "Green" and the Small Group with a Big Heart in Transportation Mode Choice. Sustainability 5, 2913-2927.

Gaker, D., Zheng, Y., Walker, J., 2010. Experimental Economics in Transportation. Transportation Research Record: Journal of the Transportation Research Board 2156, 47-55.

Greene, W.H., Hensher, D.A., 2003. A latent class model for discrete choice analysis: contrasts with mixed logit. Transportation Research Part B: Methodological 37, 681-698.

Heyman, J., Ariely, D., 2004. Effort for Payment: A Tale of Two Markets. Psychological Science 15, 787--793.

Jones, J.M., Saad, L., 2014. GALLUP poll social series: Environment. GALLUP.
Kaiser, F.G., Shimoda, T.A., 1999. Responsibility as a Predictor of Ecologicla Behaviour. Journal of Environmental Psychology 19, 243-253.
Kaiser, F.G., Wilson, M., 2004. Goal-directed conservation behavior: the specific composition of a general performance. Personality and Individual Differences 36, 1531-1544.
Leiserowitz, A., 2006. Climate change risk perception and policy preferences: The role of affect, imagery, and values. Climatic Change 77, 45-72.
Prosperity, S., 2012. British Columbia’s carbon tax shift: The first four years. University of Ottawa. Accessed March 20th from http://www/. sustainableprosperity. ca/dl872&display.
Rivers, N., Schaufele, B., 2015. Salience of carbon taxes in the gasoline market. Journal of Environmental Economics and Management 74, 23-36.
Saad, L., Jones, J.M., 2016. U.S. Concern About Global Warming at Eight-Year High, GALLUP poll Mar 2-6. GALLUP.
Sarrias, M., Daziano, R.A., 2016. Multinomial Logit Models with Continuous and Discrete Individual Heterogeneity in R: The gmnl Package. Journal of Statistical Software.
Schwartz, S.H., 1977. Normative influences on altruism. Advances in experimental social psychology 10, 221-279.
Wang, C., Daziano, R.A., 2015. On the problem of measuring discount rates in intertemporal transportation choices. Transportation 42, 1019-1038.
Waygood, E.O.D., Avineri, E., 2010a. Research and Design Report. Carbon Aware Travel Choices (CATCH).
Waygood, E.O.D., Avineri, E., 2010b. Visual Formats, Reference Points, and Anchoring Effects on Perceptions of the Sustainability of Travel Choices, The 1st Workshop on Traffic Behavior, Modeling and Optimization (TBMO10), Madeira.
Waygood, E.O.D., Avineri, E., 2011. Does "500g of CO2 for a five mile trip" mean anything? Towards more effective presentation of CO2 information, Proceedings of the Transportation Research Board 90th Annual Meeting, Washington, D.C.
Waygood, E.O.D., Avineri, E., 2013. Analytical or Emotional? Which stimulates greater sustainable travel intention?, , 92nd Annual Meeting of the Transportation Research Board, Washington, D.C.
Waygood, E.O.D., Avineri, E., 2014. Communicating Transportation Carbon Dioxide Information: Does Gender Impact Behavioral Response?, 5th International Conference on Women's Issues in Transportation, Paris.
Waygood, E.O.D., Avineri, E., 2016a. CO2 Valence Framing: is it really any different from just giving the amounts?, The 95th Annual Meeting of the Transportation Research Board, Washington, D.C.
Waygood, E.O.D., Avineri, E., 2016b. Communicating transportation carbon dioxide emissions information: does gender impact behavioral response? Transportation Research Part D: Transport and Environment 48, 187-202.

FIGURES

Imagine that you are in a situation where you must buy a vehicle. You have decided on which vehicle you want, but you must make some final decisions on the motor type. Please make your choice from the information below.
*Annual savings are based on driving 15 000 miles/year with fuel costing $3.70/gallon.

	Purchase Cost	Fuel Costs per year	(CO2 information; depending on treatment)
Car A			
Car B			

Given the 2 options above, which car would you buy? (Please inspect carefully all characteristics before making your choice)

Figure 1. Example of choice experiment question.

Highlights

CO_2 emissions information (CO_2EI) as grams/mile has negligible influence.
CO_2EI as a carbon tax is only as strong as the tax.
CO_2EI contextualised through use is roughly 9x as strong as g/mile.
CO_2EI contextualised with respect to reduction targets is 13x as strong as g/mile.

TABLES

TABLE 1 Selected results for respondent characteristics

Variable	*Respondents' characteristics*
Female	49.80%
Education	
Below High School	0.7%
High school graduate	12.2%
Associate degree	9.2%
Some college	19.8%
Bachelor's degree	38.6%
Graduate degree	19.6%
Household cars	
1	39.0%
2	46.7%
3	9.8%
4 or more	4.5%
Mileage	
Less than 5,000 miles	6.3%
5,000 - 7,500 miles	13.4%
7,501 - 10,000 miles	17.8%
10,001 - 12,500 miles	18.6%
12,501 - 15,000 miles	14.8%
15,001 - 17,500 miles	6.6%
17,501 - 20,000 miles	5.9%
20,001 - 25,000 miles	4.7%
Over 25,000 miles	11.9%
State of residence	
DE	5.4%
MA	34.2%
NH	6.6%
NJ	14.1%
PA	39.3%
Other	0.4%
Household income	
<$30,000	6.7%
$30,000-$39,999	6.6%
$40,000-$49,999	8.5%
$50,000-$59,999	10.3%
$60,000-$74,999	15.6%
$75,000-$84,999	8.4%

$85,000-$99,999	10.4%
$100,000-$124,999	11.0%
$125,000-$149,999	6.9%
$150,000-$174,999	4.2%
>$175,000	6.5%

TABLE 2 Responses to questions addressing climate change.

Question	*Options*	*Results*
1. The 2025 objective of the USA federal government is a 26-28% reduction in emissions from 2005 levels. For road transportation, this would mean an average of 3.8 tons per person per year (down from 5.2 tonnes in 2005). If you were to remain at 2005 levels (and not reduce), how much would you be willing to pay per ton of additional GHG emissions?		
	Nothing	45.2%
	$5 per ton	26.9%
	$12 per ton	15.1%
	$39 per ton	7.2%
	$61 per ton	2.7%
	$116 per ton	1.8%
	$250 per ton	0.4%
	$500 per ton	0.6%
2. How much do you support or oppose a 60-cent per gallon gasoline tax, in addition to existing gas taxes, to encourage people to drive less and thus reduce carbon dioxide emissions?		
	Strongly support	5.6%
	Rather support	13.9%
	Don't know	12.6%
	Rather oppose	26.0%
	Strongly oppose	42.0%
3. In order to encourage the use of more fuel-efficient vehicles, some people have proposed a 5 percent "gas guzzler" tax on cars, trucks and sport utility vehicles that get less than 25 miles per gallon. This would add $1,000 to the price of a $20,000 car. How much do you support or oppose this proposal?		
	Strongly support	15.1%
	Rather support	30.9%
	Don't know	14.9%
	Rather oppose	18.1%
	Strongly oppose	21.1%
4. To encourage industry to be more fuel efficient, some people have proposed a business energy tax. This tax would raise the average price of most things you buy, including food and clothing, by 3 percent, or approximately $380 per person per year. How much do you support or oppose this proposal?		
	Strongly support	5.3%
	Rather support	15.8%
	Don't know	17.8%
	Rather oppose	27.1%

Strongly oppose	34.2%

5. Please choose the phrase that most corresponds to you for reducing greenhouse gases:

I am not concerned	13.5%
I would like to reduce my emissions, but I don't know how	30.9%
I would like to reduce my emissions, and will do so in the future	39.7%
I have already reduced my emissions significantly	15.9%

TABLE 3 High loading variables for each principal component of the factor analysis on general ecological behavior and tax policy preferences variables.

Principal components	**Variables used (high loading)**
General ecological behavior	
Actively environmental (Responses were from Never (1) to Always (5))	I talk with friends about problems related to the environment. I read about environmental issues. I have pointed out unecological behavior to someone. I contribute financially to environmental organizations. I boycott companies with an unecological background. I buy products in refillable packages.
Not interested in solar panels (Responses were Yes =1; No = 2)	I requested an estimate on having solar power installed. I have already looked into the pros and cons of having a private source of solar power. I bought solar panels to produce energy.
Transportation behavior	
Multi-modal (Responses were from Never (1) to Always (5))	I take public transportation to work or school. For distances up to 20 miles, I use public transportation. In nearby areas (around 5 miles), I ride a bike. I ride a bicycle to work or school.
Drive everywhere (Responses were from Never (1) to Always (5))	I drive my car in the city. I drive my car into the city.
Idle (Responses were from Never (1) to Always (5))	I keep the engine running while waiting in front of a railroad crossing or in a traffic jam. At red traffic lights, I keep the engine running.
Rules over economics (Responses were from Never (1) to Always (5))	I drive on highways at speeds under 60 mph. I drive in such a way as to keep my fuel consumption as low as possible. (*Negative loading).
Personal ecological values and beliefs	
Against taxes to reduce emissions (Responses for 1, 2, and 3 were from strongly support (1) to strongly oppose (5). Responses for 4 were: Nothing (1), $5 per ton (2), $12 per ton (3), $39 per ton (4), $61 per ton (5), $116 per ton (6), $250 per ton (7), $500 per ton (8).)	1) How much do you support or oppose a 60-cent per gallon gasoline tax, in addition to existing gas taxes, to encourage people to drive less and thus reduce carbon dioxide emissions? 2) In order to encourage the use of more fuel-efficient vehicles, some people have proposed a 5 percent "gas guzzler" tax on cars, trucks and sport utility vehicles that get less than 25 miles per gallon. This would add $1,000 to the price of a $20,000 car. How much do you support or oppose this proposal? 3) To encourage industry to be more fuel efficient, some people have proposed a business energy tax. This tax would raise the average price of most things you buy, including food and clothing, by 3 percent, or approximately $380 per person per year. How much do you support or oppose this proposal? 4) The 2025 objective of the USA federal government is a 26-28% reduction in emissions from 2005 levels. For road transportation, this would mean an average of 3.8 tons per person per year (down from 5.2 ton in 2005). If you were to remain at 2005 levels (and not reduce), how much would you be willing to pay per ton of additional GHG emissions? (Negative loading)

Nature will not sort out environmental problems (Responses were from strongly agree (1) to strongly disagree (5))	The balance of nature is strong enough to cope with the impacts of modern industrial nations. Human destruction of the natural environment has been greatly exaggerated. Humans will eventually learn enough about how nature works to be able to control it. Humans have the right to modify the natural environment to suit their needs. Human ingenuity will insure that we do NOT make the earth unlivable. Humans were meant to rule over the rest of nature.

TABLE 4 Experiment attributes and levels

Attribute	Levels Vehicle A	Levels Vehicle B
Purchase price	80%, 90%, 105%, 115% of stated willingness to spend	90%, 110%, 120%, 130% of stated willingness to spend
Fuel costs per year	$1,500; $1,900; $2,500	$800; $1,200; $1,500
Grams of CO_2 per mile	304; 320; 336	170; 215; 260

TABLE 5 Estimated WTP with Multinomial Logit Specification

	MNL-1		MNL-2	
	Month	Year	Month	Year
Subjective discount rate: r	1.02%***	13.00%	1.09%***	13.90%
Subjective discount rate, no CO_2 Information			0.84%***	10.52%
Presentation of CO_2 Information	$/ton	¢/pound	$/ton	¢/pound
Base WTP (tons per year): ω_{tons}	245.76***	12.29	277.25***	13.86
Grams per mile: δ_{gpm}	-224.62***		-248.62***	
Pounds per month: δ_{ppm}	-33.12		-34.03	
Societal Objective: δ_{objppm}	89.09*		94.07*	
WTP Grams per mile: $\omega_{\text{tons}} + \delta_{\text{gpm}}$	21.14	1.06	28.63	1.43
WTP Pounds per month: $\omega_{\text{tons}} + \delta_{\text{ppm}}$	212.64***	10.63	243.22***	12.16
WTP Societal Objective: $\omega_{\text{tons}} + \delta_{\text{objppm}}$	334.85***	16.74	371.31***	18.57
Loglikelihood at convergence	-10655		-10632	
$\rho^2(0)$	0.190		0.192	
$\rho^2(ASC)$	0.187		0.189	
BIC	21380		21343	
AIC	21325		21281	
Significance codes: *** 0.1%, ** 1%, * 5%				

TABLE 6 Estimated WTP with 2 Latent Classes and Attitudinal Factors for Class Assignment

	LCL-1		LCL-2	
Class 1 (49.98%)				
	Month	Year	Month	Year
Subjective discount rate: r	0.44%	5.39%	0.51%***	6.29%
Subjective discount rate, no CO_2 Information			0.20%***	2.49%
Presentation of CO_2 Information	\$/ton	¢/pound	\$/ton	¢/pound
Base WTP (tons per year): ω_{tons}	259.59***	12.98	313.13***	15.66
Grams per mile: δ_{gpm}	-157.46***		-183.94***	
Pounds per month: δ_{ppm}	47.37		50.98	
Societal Objective: δ_{objppm}	59.60*		68.57*	
WTP Grams per mile: $\omega_{\text{tons}} + \delta_{\text{gpm}}$	102.13*	5.11	129.19*	6.46
WTP Pounds per month: $\omega_{\text{tons}} + \delta_{\text{ppm}}$	306.96***	15.35	364.11***	18.21
WTP Societal Objective: $\omega_{\text{tons}} + \delta_{\text{objppm}}$	319.19***	15.96	381.70***	19.08
Class 2 (50.02%)				
	Month	Year	Month	Year
Subjective discount rate: r	1.65%***	21.77%	1.67%***	21.99%
Subjective discount rate, no CO_2 Information			0.79%***	9.94%
Presentation of CO_2 Information	\$/ton	¢/pound	\$/ton	¢/pound
Base WTP (tons per year): ω_{tons}	198.42***	9.92	193.87***	9.69
Grams per mile: δ_{gpm}	-165.68***		-159.45***	
Pounds per month: δ_{ppm}	27.94		30.10	
Societal Objective: δ_{objppm}	48.54		42.74	
WTP Grams per mile: $\omega_{\text{tons}} + \delta_{\text{gpm}}$	32.7	1.64	34.4	1.72
WTP Pounds per month: $\omega_{\text{tons}} + \delta_{\text{ppm}}$	226.36***	11.32	223.97***	11.20
WTP Societal Objective: $\omega_{\text{tons}} + \delta_{\text{objppm}}$	246.9***	12.35	236.61***	11.83
Assignment to Class 2				
	Estimate	Odds Ratio	Estimate	Odds Ratio
Constant	0.817***	2.264	0.892***	2.440
Against taxes to reduce emissions	0.171***	1.186	0.190***	1.209
Nature will *not* sort out environmental problems	-0.213***	0.808	-0.233***	0.792
Actively environmental	-0.256***	0.774	-0.238***	0.788
Not interested in solar panels	0.069***	1.072	0.052**	1.053
Multi-modal	-0.033	0.968	-0.04*	0.961
Drive everywhere	-0.044*	0.957	-0.027	0.973
Idle	-0.016	0.985	-0.001	0.999
Rules (e.g. speed limit) over economics (e.g. drive to conserve fuel)	-0.051**	0.951	-0.067***	1.209
Loglikelihood at convergence	-9355		-9305	
$\rho^2(0)$	0.289		0.292	
$\rho^2(ASC)$	0.287		0.290	
BIC	18917		18837	
AIC	18752		18656	
Significance codes: *** 0.1%, ** 1%, * 5%				