Increasing the Influence of CO2 Emissions Information on Car Purchase

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Extended abstract

OVERVIEW

In response to concerns of climate change, individuals are often provided with information on greenhouse gas emissions (GHGs) whether for trips or for purchases 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 and consists of presenting grams of carbon dioxide (CO_2) per mile. On the label provided by EPA, an individual can see how the vehicle ranks according to the EPA's rating system. A top ranked vehicle produces anywhere between 0 and 236 g of CO_2 per mile (147 g/km). The actual amount produced in grams of CO_2per mile is written in a faded print below the scale on the EPA's label system.

The current information on CO_2 emission place a heavy burden of knowledge on the consumer to know what the limits are, what the average consumption of the product might be and to estimate whether the consumption exceeds the threshold. In such a situation, one might first question whether providing CO_2 emission information has any impact on choice at all.

Previous research has found benefits of providing this information on vehicle choice (Gaker et al. 1-3, 4-5), but other research has also questioned whether how this information is presented might affect choice (6-7). That latter research argues that CO_2 emission information generally lacks contextualization that allows for interpretation (8-9).

Whether providing people with only CO_2 mass information would influence their choices may also relate to how environmentally motivated they are (8 and 1-3). Thus, the problem may be that providing simply CO_2 mass may require an individual to be environmentally motivated (8; 10).

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 being confident to rank the information or by the likelihood of a behavioral response (e.g. would they consider changing their travel behavior) (8; 11; 12). Such contextualization provides an interpretation of the amount with respect to an authority's evaluation of what is acceptable or not. Such a method of presenting the information could be considered an injunctive norm as it would communicate to the 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.

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. This research will attempt to combine those approaches and determine whether changing how the information is presented will have a significant impact on vehicle choice through a willing-to-pay choice experiment using latent class modeling.

METHOD

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

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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 survey involved a Discrete Choice Experiment prior to the questions on ecological behavior and environmental attitudes. 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. (2-3).

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 attributes and the levels used in the experiments are summarized in Table 1. 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 26% from 2005 levels.

TABLE 1 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

Whereas the 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 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 and CO_2 presentation treatment were randomized.

Structural model

To analyze choices made by the 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:

$$\mathrm{U}_{ij} = \beta_{\mathrm{price,i}}\left[\mathrm{price}_{ij} + \mathrm{PVFC}_{ij} + \mathrm{PVFE}_{ij}\right] + \varepsilon_{\mathrm{i}j},$$

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 $-\beta_{\mathrm{price,i}}$ is the parameter that represents the marginal utility of income.

If both emissions and operating costs (oc_{ij}) are measured in a per-month basis and if oc_i is the monthly uniform equivalent of the future operating costs, and $\mathrm{emissions}_i$ is the monthly uniform equivalent of the future emissions, and if the number of months of ownership is large (the average American keeps a car for 11 years), then it is possible to rewrite the choice model as:

$$U_{ij} = \beta_{\text{price}}\left[\text{price}_{ij} + \frac{oc_{ij}}{r_i} + \frac{\omega_{\text{E,i}}}{r_i}\text{emissions}_{ij}\right] + \varepsilon_{ij},$$

where r_i is the subjective discount rate 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).

Two different discrete choice model formulations were used: a base Multinomial Logit, and a Latent Class Mixed Logit. 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:

$$U_{ij} = \beta_{\text{price}}\text{price}_{ij} + \frac{\beta_{\text{price}}}{r}\left[oc_i + \text{tax}_i D_{\text{tax}} + (\omega_{\text{tons}} + \delta_{\text{gpm}}D_{\text{gpm}} + \delta_{\text{ppm}}D_{\text{ppm}} + \delta_{\text{obj}}D_{\text{obj}})\text{tons}_i\right] + \varepsilon_{ij},$$

Here, D_{tax} is 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 societal objective.

RESULTS

The subjective discount rates and WTP for CO_2 emission reductions, both estimated with the base Multinomial Logit and Latent Class Mixed Logit models, can be found in Table 2. Subjective discount rates are presented by month and by year. The models were estimated simply as a function of price and operating cost. As a result, only one subjective discount rate was estimated per model.

TABLE 2 Estimated WTP with Multinomial Logit and Latent Class Mixed Logit Specification

	MNL		Latent Class Mixed Logit	
			Class 1 (54%)	*Class 2 (46%)*
	Month	Year	Month	Month
Subjective discount rate*** : r	1.02%	13.00%	0.29%	1.76%
Presentation of CO_2 Information	$/ton	¢/pound	$/ton	$/ton
Base (tons per year): ω_{tons}	190.52***	9.53	188.80***	237.07***
Pounds per month: $\omega_{\text{tons}} + \delta_{\text{ppm}}$	198.38	9.92	209.93	250.86
Societal Objective: $\omega_{\text{tons}} + \delta_{\text{objppm}}$	257.83**	12.89	255.77*	265.20
Grams per mile: $\omega_{\text{tons}} + \delta_{\text{gpm}}$	47.16***	2.36	47.38***	30.52***
Significance codes: *** 0.1%, ** 1%, * 5%				

The subjective discount rate estimated with this first model was 1.02% on a monthly basis, and 13.00% on an annual basis. Compared with typical automotive market discount rates of 5-7% per year (27), this result 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 (13). In fact, estimates were found ranging from 9.6% to 47% derived from 20 studies between 1980 and 2012.

With respect to estimates of WTP for CO_2 reductions, when CO_2 emission information was presented as tons per year (base case), respondents were willing to pay \$190.52 (¢9.53) to reduce CO_2 emissions by one ton (pound). 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.

When CO_2 information was presented to respondents as pounds per month, the result of \$198.38 (¢9.92) per ton (pound) is very close to, and not statistically significantly from, the base case. When CO_2 information was provided to respondents in the form of a societal objective, however, the WTP estimate was much larger, and statistically significantly different, with a value of \$257.83 (¢12.89) per ton (pound). Finally, when CO_2 information was presented as grams per mile, a very different (and far lower) WTP was estimated at \$47.16 (¢2.36) per ton (pound). This result was also statistically significantly different. Thus, the first hypothesis, "presenting CO_2 emissions information as grams/mile will result in lower willingness to pay" is confirmed.

Latent Class Mixed Logit model formulation was used 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. After testing specifications with different numbers of classes, the best model (in terms of goodness of fit, statistical significance of variables, etc.) 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.

The latent class model indicates a discrete distribution in which some people are more influenced by CO_2 emissions information; though not when presenting it as grams per mile. Their willingness to take on personal costs for the public benefit is most apparent when not contexualizing (55% difference for grams per mile), then when only contextualizing by averages per year (25%), though which class is influenced more is reversed. The least affected by class assignment was the societal goal contextualization (4%). 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 positively affects WTP for all types of CO_2 information except for grams per mile, is informed by attitudinal latent factors inconsistently.

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 (i.e. the standard presentation of CO_2 information on EPA labels). It is in fact only one quarter of the estimate when information is provided in tons per year (the base) for the Latent Class 1, and only 12% for the Latent class 2. 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 fourfold increase in the influence of such information on car purchase choices.

Another remarkable result is how much higher WTP is when CO_2 information is presented as a societal goal. 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.

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