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ABSTRACT
Understanding the roots of policy perception can be critical for informing the design and implementation of innovative public policies. Feebates is one such innovative policy and in the context of new vehicles can be designed to offer buyers a rebate for the purchase of low-emission vehicles and a fee for the purchase of high-emission vehicles. Because feebates is a policy that directly impacts the consumer, understanding the dynamics of public perception, support, and opposition is important. This study explores the public perception of a feebate policy within California and evaluates the robustness of ordinal regression models to predict policy sentiment. The authors conducted a series of 12 focus groups throughout the State, which were followed by a computer-assisted telephone interview (CATI) survey of 3,072 California residents in Fall 2009. The survey results were used to gain insights into the consumer response to a feebate policy, while focus groups gauged participant understanding of the feebate concept and overall response in preparation for the statewide survey. The survey data was weighted to match key demographics of the population and probed respondents on sentiments towards climate change, foreign oil dependence, policy fairness as well as perceptions of a potential California feebates policy. The results suggested that roughly three quarters (~76%) of the population would have supported a feebate policy, while one-in-five (~22%) would have opposed it. To evaluate how key factors simultaneously influence policy support/opposition, the authors estimated an ordinal regression model on policy support, which could correctly re-predict 89.4% of the sample's policy support or opposition. To further assess the model's robustness, it was validated through a series of re-estimations with 10,000 randomly drawn subsamples. Models estimated using these subsamples were then applied to predict policy opinion on the remaining hold-out sample. The model performed very well, as hold-out sample opinions could be predicted with an average accuracy of 89.1%, with little variance in performance. The authors conclude with a discussion of the implications of these results on public support for feebates and comment on the use of ordinal regression to predict policy opinion.

KEY WORDS: Feebate policy, motor vehicle, climate change, fuel economy, ordinal regression, cross-validation

1. Introduction

Transportation activity contributes about 27% of annual greenhouse gas (GHG) emissions in the United States (U.S.), with more than 90% fueled by petroleum. Cars and light duty trucks, which comprise almost two thirds of the sector's energy use, are responsible for nearly 44% of all U.S. oil consumption (Davis et al., 2012). Reducing this consumption has been a public policy objective for decades, and a variety of policies have been proposed and adopted.

One such proposed approach is a feebate policy. A traditional feebate policy is generally comprised of two parts: a rebate (price reduction) for the purchase of a low-emission vehicle and

a fee (price increase) for vehicles that produce higher emissions. Most feebate policies have focused on GHG emissions, but they can also consider other air pollutants or fuel economy as benchmarks. A "pivot point" of the policy identifies the level of vehicle emissions at which the feebate changes from granting a rebate to imposing a fee (German and Meszler, 2010). One advantage of feebates is that the policy funds itself either in whole or in part with the fee supporting the rebate. A common policy objective is revenue neutrality, such that additional governmental support is not required. In addition, by shifting consumer preferences and demand, feebates may be able to indirectly encourage manufacturers to adopt new technologies and lower vehicle emissions per mile (Greene et al., 2005a,b). Recently, Liu et al. (2011) modeled the impact of a feebate policy on new vehicles in California using estimates for new vehicle sales and a vehicle stock model. They found that feebates could be effective in reducing GHG emissions and result in an annual reduction of GHG emissions between 19.6 to 28.4 million metric tons (Mt) of carbon in California by 2020 (if implemented in 2011) depending on the policy design. Furthermore, Small (2012) conducted a simulation of several feebate policy designs and found that it would be about as effective as a policy he calls a "Pavley CAFE," in which federal standards for fuel efficiency follow those adopted by California through Assembly Bill 32 (52 mpg average by 2020).

Previous feebate studies have focused primarily on the impact that feebates would have on manufacturers and vehicle design and the subsequent impacts on air quality and/or GHG emissions. There has been less research on understanding the public's perception of a feebate policy. This paper characterizes this perception in California through the analysis of a statewide survey and focus groups held in late 2009. The authors also evaluate the relative influence of socioeconomic and attitudinal variables on policy through the estimation of an ordinal regression model to predict policy opinion. We then explore the robustness of using the model to predict policy perception for a population by splitting the sample into two subsamples: one for coefficient estimation and the other for prediction. By repeating this process with many subsample draws, we establish the distribution of prediction accuracy. This approach is useful for evaluating the robustness of ordinal regression models and, in this case, shows that the model is quite reliable in its policy perception prediction accuracy of about 90%.

The paper is organized into six main sections. First, a brief review of past feebate programs and research is provided. Next, the study methodology and sampling frame are outlined. Third, basic survey and focus group results are discussed. Fourth, we present the ordinal regression model, and then fifth, evaluate its robustness. Finally, we conclude with a discussion of key points emerging from the analysis.

2. Past Feebate Policies and Research in Feebate Public Perception

As of 2012, there are no U.S. feebate policies in effect. However, there are feebates policies on vehicles enacted in several other countries including France, Canada, and the Netherlands. Within the U.S., several states attempted to establish such policies during the 1990s and early 2000s. A policy similar to feebates, called "DRIVE+" (Demand-based Reductions in Vehicle Emissions PLUS Improvements in Fuel Economy), was proposed in California in 1990.

DRIVE+ sought to establish a sales tax surcharge on vehicles with high carbon dioxide and criteria pollutant emissions and a sales tax reduction for more fuel efficient and lower emitting vehicles (Levenson and Gordon, 1990). Despite passing through the legislature, the proposal was vetoed by the Governor. In 1991, the Maryland legislature passed a feebate policy, but it was challenged by the Bush administration under the premise that it encroached on the federal jurisdiction over fuel economy standards. As a result, Maryland did not enact the policy, and it was repealed in 2001 (Langer, 2005). California nearly passed the "Clean Vehicle Discount Program" under AB493 in 2007, which would have provided incentives of up to $2,500 per vehicle and fees of up to the amount of the sales taxes on the vehicle, but it failed to pass in the state legislature. In contrast, feebates have gained greater traction in Europe and Canada where they have become a centerpiece of vehicle emission policies during the previous decade. For example, France, Austria, Denmark, Norway, the Wallonia region of Belgium, and the Netherlands all have had some form of a feebate policy in recent years. In Canada, Ontario's feebate policy emerged from a 1989 tax on fuel inefficient passenger vehicles after a rebate was introduced in 1991 (Barg et al., 1995).

While most feebate research has focused on policy impacts, some have touched on the public perception of feebate policies with conflicting results. A 2008 survey of California adults revealed strong support for green transport taxes. Sixty-six percent of those surveyed were in support of a feebate policy, with respondents in Northern regions and those affiliated with Democrats more supportive (Agrawal et al., 2010). In contrast, a survey conducted by the Consumer Federation of America in 2009 showed that 54% of Americans did not support a feebate policy. This same survey indicated that 78% of Americans approved of increasing fuel economy requirements from 27 miles per gallon (MPG) to 35 MPG in 2016, however (CFA, 2009). A 2009 survey by the National Survey of American Public Opinion on Climate Change showed that 49% did not support a gas tax increase to reduce GHG emissions, while 44% supported an increase in vehicle fuel efficiency even if this resulted in increased vehicle costs (Rabe and Borick, 2010).

While understanding of public reaction to feebates has been limited, some proponents have emphasized program features that preserve equity as a strategy to gain higher public acceptance. The Connecticut Clean Car Incentive suggests creating a class-based feebate in which vehicles are compared within their class and presented with fees/rebates based on class performance (Connecticut Department of Environmental Protection, 2006). McManus (2007) and Bunch and Greene (2010) also discuss a feebate with a "zero-band" or a collection of vehicles left unaffected by the policy.

Public policies influencing vehicle choice and technology are designed with the intent to mitigate the externalities (e.g., GHG and air emissions) associated with collective vehicle use. The public's perception of the risk of these externalities is naturally influential on the support for such policies. Relative to other countries in the world, the U.S. public has demonstrated less concern about climate change (Pew Research Center 2009). But this sentiment moves, as in 2012 67% of Americans agreed that there is solid evidence of global warming. This was an increase from the nadir of 57% in 2009, but a decline from 77% in 2006 (Pew Research Center 2012).

The degree of climate change concern is also related to gender, education, and political affiliation. McCright (2010) and Semenza et al. (2008) have shown that women are more concerned about climate change than men. Moreover, Dunlap and McCright (2008) highlight the partisan split between Democrats and Republicans in environmental issues. This division on the issue of climate change is found annually by Pew surveys on the topic (Pew Research Center 2012).

Overall, previous research has suggested that the public has had mixed opinions about feebate policies. Furthermore, feebate response may evolve over time and be regionally distinct, with certain areas of California and the country more likely to support a feebate policy than others.

3. Methodology

To evaluate support for feebates within the state and to identify the key determinants of policy perception, this study applied both qualitative and quantitative methods. To gain qualitative perceptions, researchers held 12 focus groups during August and September 2009 in which participants were presented with a variety of feebate policy designs and asked to discuss their reactions and opinions regarding the feebate concept, as well as three distinct feebate policy designs. This was followed by an in-depth discussion of the perceived benefits and drawbacks of each design and policy option. Participants then shared their perceptions of climate change and their opinions regarding feebates overall. The focus groups were held with locally recruited participants in the San Francisco Bay Area, the Central Valley, the Los Angeles area, Sacramento, and San Diego. A total of 165 persons were recruited for the focus groups from which 120 were selected to form groups of eight to ten.

The survey design was informed by the focus group input and completed between October and December 2009. The sample was drawn using a random digit dialing approach from a total of 31,790 usable numbers. Screening criteria included California residency for at least nine months of the year, plans to purchase or lease a vehicle within the next 15 years, and the ability to speak either English or Spanish. The survey was 13 to 16 minutes in length and consisted of 36 questions.

Before any questions were asked of the participant about his or her opinion on feebates, researchers introduced the feebate concept and policy design in the telephone survey. A simple policy design was described, in which the fees and rebates on vehicles increased with distance from an established target emission rate. This design was explained precisely as follows (capitalized words emphasized by the interviewer):

> *I would like to describe a transportation program for NEW vehicle buyers. Under this program, when a new vehicle is FIRST purchased, it could be subject to either a one-time fee or a one-time rebate. The program sets a target for vehicle emissions. If you buy a vehicle with emissions higher than the target, you have to pay a fee. If you buy a vehicle with emissions lower than the target, you get a rebate. The amount of the fee or rebate depends on the vehicle's greenhouse gas emissions. Vehicles with the lowest emissions—*

> *and highest MPG—get the biggest rebates. Vehicles with the highest emissions—and lowest MPG—get the biggest fees. The program is designed to help reduce California's greenhouse gas emissions.*

Interviewers then asked participants about feebate opinions, as well as impressions of policy effectiveness and fairness. Following this definition, the respondents were asked a series of questions designed to capture their overall sentiment towards the policy. These questions were given in the form of statements, and respondents were asked to state whether they agreed or disagreed with the statement using a 4-point Likert scale with the options of: "Strongly Agree," "Agree," "Disagree," and "Strongly Disagree." The survey also included demographic information, existing vehicle ownership, future vehicle choice, and general political views including their opinions on environmental issues, such as climate change.

Several steps were taken to complete the survey analysis of statewide feebate perception. The survey sample exhibited some departure from the general population along certain demographic attributes. To adjust for this departure, the sample was weighted with post-stratification weights that were derived from the 2006 to 2008 American Community Survey (ACS) Public Use Microdata (PUMS) of California (U.S. Census Bureau, 2008). Before applying the weights, non-responses to these questions were imputed using the "hot deck" method, which relies on the sample joint distribution of influential attributes and the random ordering of existing respondents to generate an imputed estimate of missing values. This method imputed values for income, education, and age. The post-stratification weights were then derived from the joint-distribution of these attributes in the PUMS dataset and the survey sample. This weighting did realign the sample demographics with the population (as shown in Table 1 in the analysis) and shifted opinions slightly. However, this shift in opinion was not dramatic enough to alter any overall conclusions from the sample.

To understand the underlying attributes influencing the perception of feebates, we estimate an ordinal regression model with policy perception as the dependent variable. This allows us to identify which demographic and attitudinal variables are most influential on the support or opposition to the policy while controlling for other variables. Further, the prediction accuracy of this model is evaluated and then validated using a series of hold-out samples. This cross-validation procedure begins by 1) randomly selecting 50% of the respondents from the complete sample, 2) re-estimating the model coefficients using this subsample, 3) applying this new estimation to predict the policy opinion of the remaining 50% (hold-out) subsample, and 4) recording the accuracy of this prediction as a percent of respondents' opinions correctly predicted. We repeat this procedure 10,000 times, each time drawing a new estimation subsample and predicting the policy opinions of the independent hold-out sample. This procedure allows us to assess the robustness of the model structure (and its coefficients) for predicting the opinions of independent respondents not used to inform the model coefficients.

3.1 Study Limitations

For much of the study population, feebate policy was a new and unfamiliar concept. This study had to introduce the policy concept and then solicit reactions to it. This is a common challenge when evaluating public opinions of experimental ideas. While the feebate survey data provide insights into the opinions of a large sample of Californians, self-selection bias can occur in telephone surveys in spite of random sampling and other oversampling methods to mitigate them, as populations with certain demographics have a higher propensity to respond to telephone surveys than others (particularly, older and more Caucasian cohorts in CATI surveys) (Triplett, 2005). As described above, the sample was weighted to re-align it with the population on key demographics.

Finally, while the focus groups provided a rich qualitative setting for group interactions on feebates and identified key trends, those interactions can influence the results. Dominant personalities can influence other respondents and the overall sentiment in the room. Focus groups are also limited in size and are not quantitative in nature, limiting the degree to which generalizations can be formed. Focus groups are more useful for identifying perceptions and thoughts in detail that can be useful for informing survey design.

4. Survey and Focus Group Results

The survey and the focus group results produced distinct perspectives on the reactions of Californians to the feebate concept. The focus groups illustrated more in-depth reactions to specific policy designs, whereas the survey provided a more robust sample for evaluating personal opinions. Table 1 illustrates the demographic profile of the focus groups, the survey sample, and the weighted sample, as compared to the California population (18 years or older).

Table 1 Demographic Profile of Statewide Feebate Policy Focus Group and Survey Participants in Comparison with California Population

Demographic Attribute	Focus Groups	Raw Survey	Reweighted Survey	California Population
Gender	N = 97	N = 3072	N = 3072	N = 27,043,417
Male	48.5%	47.2%	47.2%	49.6%
Female	51.5%	52.8%	52.8%	50.4%
Age Category	N = 97	N = 3072	N = 3072	N = 27,043,417
18 - 24	18%	4%	12%	14%
25 - 34	29%	11%	20%	19%
35 - 44	21%	17%	21%	20%
45 - 54	21%	25%	20%	19%
55 - 64	4%	24%	14%	13%
65 - 74	2%	14%	8%	8%
75 or over	5%	6%	6%	7%
Total	100%	100%	100%	100%
Education	N = 97	N = 3072	N = 3072	N = 27,043,417
Did not complete high school	2%	6%	17%	20%
High school graduate	3%	10%	23%	24%
Some college	35%	18%	25%	23%
2-year college degree	15%	12%	7%	7%
4-year college Degree	22%	28%	18%	17%
Graduate Degree	23%	25%	10%	9%
Other	0%	0%	0%	0%
Total	100%	100%	100%	100%
Income (Households, $ US)	N = 97	N = 3072	N = 3072	N = 12,177,852
Less than $10,000	4%	4%	6%	5%
$10,000 to $25,000	10%	9%	12%	14%
$25,000 to $35,000	10%	8%	8%	9%
$35,000 to $50,000	15%	11%	13%	13%
$50,000 to $75,000	29%	17%	18%	18%
$75,000 to $100,000	14%	16%	14%	13%
$100,000 to $150,000	16%	18%	16%	15%
More than $150,000	2%	16%	12%	13%
Total	100%	100%	100%	100%
Race	N = 97	N = 3072	N = 3072	N = 27,043,417
Caucasian or White (alone)	36.1%	55.8%	44.5%	42.6%
Hispanic	30.9%	24.5%	36.9%	36.1%
African American	14.4%	5.2%	5.5%	6.0%
Asian	18.6%	8.2%	6.1%	12.1%
Native American or Alaskan Native	0.0%	2.4%	2.7%	0.5%
Hawaiian or Pacific Islander	0.0%	1.0%	1.3%	0.3%
Other	0.0%	2.7%	3.0%	2.4%
Total	100.0%	100.0%	100.0%	100.0%
Refused	0%	1%	2%	0.0%

Table 1 illustrates the distribution of gender, income, age, education, and race within each sample against the population. The population distributions are based on the 2006 to 2008 three-year ACS estimates. In comparison to the California population, the focus group participants were younger, more educated, of higher income, and over-represented African-Americans and Asians, while under representing Caucasians and Hispanics. In contrast, the survey respondents were relatively older and more Caucasian. Similar to the focus groups, the survey respondents were more educated and had higher income. The weighting of the raw survey sample re-aligned the sample distributions more closely to the population distributions of age, education, income, as well as race.

To gauge the respondent understanding of the fundamental issues behind the policy, the survey introduced the concept of GHGs and feebates. Each respondent was first read a statement that briefly introduced them to the relationship between GHG emissions and fuel economy. The statement was followed by an initial question that assessed whether they understood the term "greenhouse gases." This was followed by a question that asked them whether they understood the term "climate change." The responses showed that 92% of the raw sample was familiar with the term "climate change," while 80% were familiar with "greenhouse gases." The weighting of the sample shifted the response slightly, with 87% familiar with "climate change" and 71% familiar with GHGs. Regardless of whether the respondent gave a "yes" or "no" answer to these questions, all were read a definition of GHGs, followed by a definition of a basic feebate policy as it could be applied in California. In the focus groups, different attitudes about climate change emerged in different geographic regions. For example, participants in Fresno and Irvine were less aware of the term "greenhouse gases" and the pollutant contributors to climate change, while participants in Oakland demonstrated a stronger understanding of climate change and tended to believe human activity was a contributing factor.

To evaluate policy support in the survey, respondents were asked a Likert-scale question that was used to gauge policy support or opposition, which read "I would generally be supportive of this kind of program to help slow the rate of climate change." Those that stated "Agree" or "Strongly agree" were considered to be in support, whereas those that stated "Disagree" or "Strongly disagree" were considered to be in opposition. For both the raw and weighted samples, a majority stated that they would generally be supportive of the feebate policy. The weighted sample shifted the distribution of opinion slightly towards the center of the four-point scale. That is, the reweighted sample contained more respondents that agreed versus strongly agreed, and more respondents that disagreed versus strongly disagreed. But in both the raw and weighted samples, roughly 76% said that they would be supportive of the policy, while the remaining 22% was opposed. In contrast, reception to the feebate concept among the focus groups was far more varied, although the overall response was more negative. Perceptions varied based on the location of the focus group. In Oakland and Sacramento, the feebate concept was received more favorably than in Southern California and the Central Valley.

While the reweighting caused notable demographic shifts in the sample along the lines of income, education, race, and age, the corresponding shift of opinion was comparably non-evident. To evaluate whether respondent location mattered more, the PUMS weighted sample

was also reweighted to match population shares in each county. The regions proportionally under-represented by the sample were urban areas, such as Los Angeles, Orange, and Alameda Counties. Overall, regional weighting of the respondents had little additional impact on overall policy opinion, shifting it towards greater feebate support. Due to this small difference, the analysis that follows reports on the PUMS weighted sample results. The cross-tabulation of opinions by income, age, race, education, and politics offer a more in-depth understanding of how opinions vary by demographics. Table 2 shows the cross-tabulation of Likert response to policy support as classified by education, income, race, age, and politics. Since the raw sample and weighted sample results do not differ significantly, only the PUMS weighted sample findings are presented.

Table 2 Cross-Tabulation of Feebate Policy Support by Education, Age, Race, Income, and Politics

EDUCATION (a)	Did not complete high school	High school graduate	Some college	2-year college degree	4-year college Degree	Graduate Degree	Total (Same for all)
Strongly Agree	23%	26%	21%	30%	28%	40%	26%
Agree	62%	49%	51%	43%	45%	40%	50%
Disagree	7%	18%	18%	16%	14%	12%	15%
Strongly Disagree	4%	6%	7%	9%	9%	6%	7%
Don't know	4%	1%	2%	2%	3%	2%	2%
Refused	1%	0%	1%	0%	0%	0%	0%
Total	520	722	754	228	554	294	3072

AGE (b)	18 - 24	25 - 34	35 - 44	45 - 54	55 - 64	65 - 74	75 or over
Strongly Agree	17%	24%	27%	33%	30%	23%	20%
Agree	62%	52%	52%	44%	46%	44%	43%
Disagree	18%	15%	9%	13%	13%	20%	29%
Strongly Disagree	2%	6%	8%	9%	7%	6%	4%
Don't know	0%	2%	3%	1%	3%	7%	3%
Refused	0%	0%	1%	1%	0%	0%	1%
Total	362	604	653	601	429	248	176

RACE (c)	Caucasian	Hispanic	African American	Asian	Native American	Hawaiian or Pacific Islander	Other	Refused
Strongly Agree	27%	27%	22%	24%	20%	23%	21%	16%
Agree	41%	58%	64%	54%	64%	55%	38%	43%
Disagree	19%	10%	11%	13%	10%	11%	26%	22%
Strongly Disagree	11%	2%	4%	4%	2%	2%	11%	13%
Don't know	2%	2%	0%	4%	4%	9%	4%	5%
Refused	0%	1%	0%	0%	0%	0%	0%	0%
Total	1342	1114	165	184	81	39	90	56

INCOME (d)	Less than $10,000	$10,000 to $25,000	$25,000 to $35,000	$35,000 to $50,000	$50,000 to $75,000	$75,000 to $100,000	$100,000 to $150,000	More than $150,000
Strongly Agree	29%	30%	24%	20%	32%	22%	25%	26%
Agree	60%	56%	59%	54%	49%	50%	42%	40%
Disagree	9%	11%	13%	14%	12%	18%	18%	19%
Strongly Disagree	2%	1%	3%	8%	5%	7%	12%	12%
Don't know	0%	2%	1%	3%	1%	3%	2%	3%
Refused	0%	0%	1%	0%	0%	0%	1%	1%
Total	185	365	260	406	560	426	487	383

POLITICS (e)	Very liberal	Liberal	Moderate	Conservative	Very conservative	Other	Not sure	Refused
Strongly Agree	53%	39%	27%	17%	11%	11%	15%	13%
Agree	35%	51%	52%	49%	31%	74%	57%	49%
Disagree	8%	7%	16%	20%	28%	8%	13%	23%
Strongly Disagree	3%	2%	4%	11%	27%	5%	7%	9%
Don't know	1%	1%	2%	3%	1%	2%	8%	3%
Refused	1%	0%	0%	1%	2%	0%	0%	2%
Total	172	706	926	738	205	112	151	62

Table 2(a) shows, across all education levels, that 70 to 80% of respondents supported the feebate policy. The greatest support (85%) was among those that did not complete high school. Interestingly, feebate support fell most among those with college degrees or experience, but no graduate degrees. The distribution in Table 2(b) shows that younger populations exhibited a

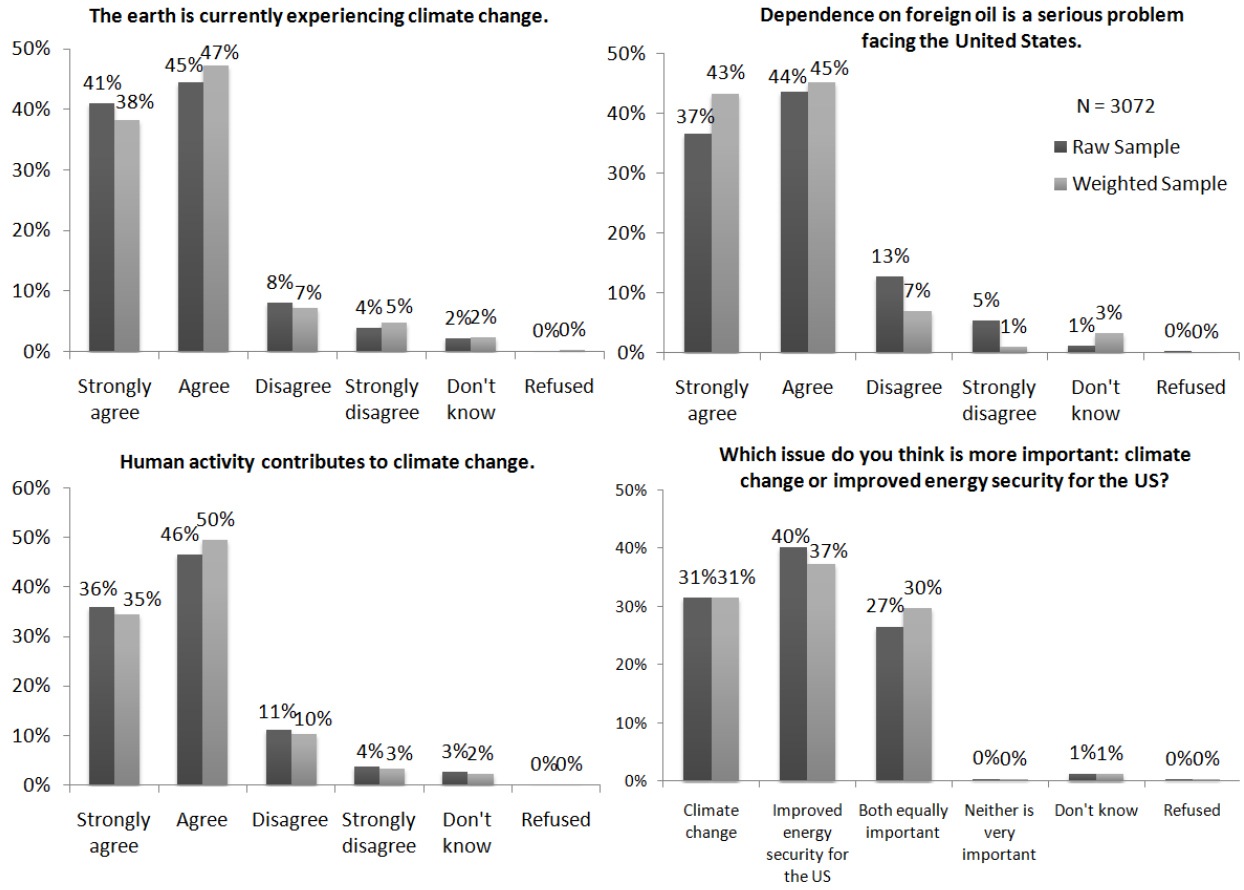
higher level of support, as 79% of the 18 to 24 year old cohort supported the policy. The level of policy support then declined gradually with age down to 63% of those 75 and older. However, the ordinal regression model presented later suggests that this may be more related to higher income, which is usually correlated with higher age. Table 2(c) shows that 30% of Caucasians opposed feebates. For the remaining ethnic groups, the proportion of the cohort opposing feebates fell within the range of 10 to 20%, without considerable differences across race or ethnicity.

Income and age are often correlated and hence the distributions exhibited similar patterns. Table 2(d) shows that opposition peaked at ~30% at the highest income category. Table 2 broadly shows that support and opposition tended to cut across most demographic attributes rather uniformly. However, political philosophy seems to influence respondent feebate position more directly.

As shown in Table 2(e) the distribution of feebate policy position was more strongly influenced by respondent political alignment. Roughly 90% of those that were liberal or very liberal were supportive of the policy. In the center, 79% of moderates, the largest political cohort, were also in support. While 66% of self-described conservatives were in support but only 42% of those self-described as “very conservative” stated that they would support the described feebate policy.

Respondents were asked questions on their views of specific environmental issues related to the feebate policy. They were asked whether they believed that climate change was happening, whether humans were causing it, and whether they thought foreign oil dependence was a serious problem for the U.S. In addition, respondents were asked to compare the importance of climate change and energy security. Figure 1 shows the response distribution from the raw and weighted sample to all of these questions.

Figure 1 Distribution of Response to Climate Change and Energy Security



The distributions show that a large majority of Californians believed that the earth is experiencing climate change and that humans are contributing to it. Based on the weighted sample, the top left graph of Figure 1 suggested that roughly 85% of the population agreed or strongly agreed that the earth is experiencing climate change. A similar share (85%) also agreed or strongly agreed that human activity is contributing to climate change. These estimates compare with U.S. national surveys that have shown the level of belief that the earth is getting warmer "based on solid evidence" has fluctuated somewhat from 2008 through 2011 but is about 20 percentage points lower than these California figures. One compilation of polls show that U.S. national levels of belief in climate change were about 65% in Fall 2009, fell to about 50% in Spring 2010, and then rebounded to about 62% in Fall 2011 (Borick and Rabe, 2012).

The two graphs on the right side of Figure 1 show the results of the energy security questions. Based on the weighted sample, the distribution of the top right graph in Figure 1 suggests that a vast majority (88%) of the population believed that foreign oil dependence is a serious concern. The bottom right graph suggests that more people (~40%) in the California population consider improved energy security for the U.S. to be more important than climate change. In contrast, 31% of respondents considered climate change to be more important. Nearly 30% of the population considered both climate change and energy security to be equally important.

5. Estimation of Ordinal Regression Model

Building on these basic summaries of data, we proceed to develop additional insights through the estimation of an ordinal regression model, using the ordinal measure of policy support as the dependent variable. The model enables better understanding of which variables are most influential on policy support, while controlling for the simultaneous influence of other variables. It also provides a mechanism for predicting policy support for different populations, and we apply a cross-validation method to evaluate the performance of our best model to accurately predict policy support and opposition within the sample.

The ordinal regression model is estimated using demographic and attitudinal variables. Variables that had a ratio or ordinal scale are applied as covariates, while variables with categorical responses are applied as factors. All ordinal regression models require the selection of a link function. The appropriate link function improves model fit and maintains model validity, as measured by the test of parallel lines. Because the sample was mostly supportive of the feebates policy, the most appropriate link function is the complementary log-log function. Due to the removal of missing responses, 2,473 valid observations were available. We begin with the "best" model estimated using the complete sample with the ordinal package on R 2.15.1. This model had a Nagelkerke score of 0.86 and is presented in Table 3.

Table 3 Ordinal Regression Model Estimation Results

Dependent Variable Threshold Coefficients		Coefficient	Std. Error	p-value
Strongly Disagree | Disagree		1.903	0.388	0.000
Disagree | Agree		3.570	0.389	0.000
Agree | Strongly Agree		5.871	0.399	0.000
Covariate Variables		**Coefficient**	**Std. Error**	**p-value**
Global warming is happening		0.443	0.044	0.000
Humans cause global warming		0.400	0.043	0.000
Foreign oil dependence is a problem		0.129	0.043	0.003
Education		0.025	0.016	0.119
Income		-0.073	0.016	0.000
Age		0.019	0.020	0.340
Maximum fuel economy		0.009	0.005	0.071
Feebates is a fair policy		0.792	0.038	0.000
Feebates is a an unfair policy		-0.294	0.038	0.000
Number of kids 18 and under		0.039	0.024	0.102
Factor Variables		**Coefficient**	**Std. Error**	**p-value**
Race or Ethnicity	Caucasian	0.425	0.185	0.022
	Hispanic	0.771	0.193	0.000
	African American	0.463	0.216	0.032
	Asian	0.533	0.205	0.009
	Native American	0.491	0.263	0.061
	Pacific Islander	0.480	0.328	0.144
	Other	0.547	0.246	0.026
Political Alignment	Very Liberal	0.450	0.242	0.062
	Liberal	0.275	0.212	0.194
	Moderate	0.123	0.206	0.551
	Conservative	-0.097	0.208	0.641
	Very Conservative	-0.491	0.227	0.031
	Other	-0.156	0.278	0.574
	Not Sure	0.356	0.266	0.182
Parallel Lines Test: (p = 1.000)				

The model structure is depicted in three sections—threshold coefficients, covariate variables, and factor variables. The threshold coefficients are much like intercept terms that apply to different levels of the dependent variable. Some key insights emerge from the values of the covariate and factor values. Positive coefficients indicate that the variable increases policy support. The model shows that increased concerns about climate change and foreign oil dependence as problems are significant and influence feebate support. The sociodemographic variables of education, income, and age reveal that income is the most significant variable, and higher levels of income reduce

policy support. This result, which emerged in many models, shows that increased income, more than age, is responsible for the reduced share of older respondents expressing feebates support. Respondents were asked whether they thought the policy was fair, and they were also asked whether the policy was unfair (a person could say that the policy was both fair and unfair). In both the raw and weighted sample, roughly 70% of respondents felt the policy was fair. Within the focus groups, perception of feebate fairness was also raised as an important issue, particularly for those with large families and businesses that require larger vehicles. Similarly, perceived feebate fairness (and unfairness) emerged as significant explanatory variables in the model. As part of the survey, the global warming and fairness variables were on the same four-point Likert scale; a comparison of the coefficients shows that perceived fairness (0.792) is almost twice as influential on policy support as the acknowledgment that humans cause global warming (0.400). Thus, perceived feebate fairness (in whatever design) may be critical to a positive public perception.

The number of children in the household had a small positive coefficient and is statistically significant. This indicates that large families were not uniformly opposed to feebates. In fact, on the contrary, the data showed that smaller households were more opposed to the feebate policy. Not surprisingly, the fuel economy of the most efficient vehicle in the household is statistically significant, indicating that those with more efficient vehicles would be more supportive of feebates.

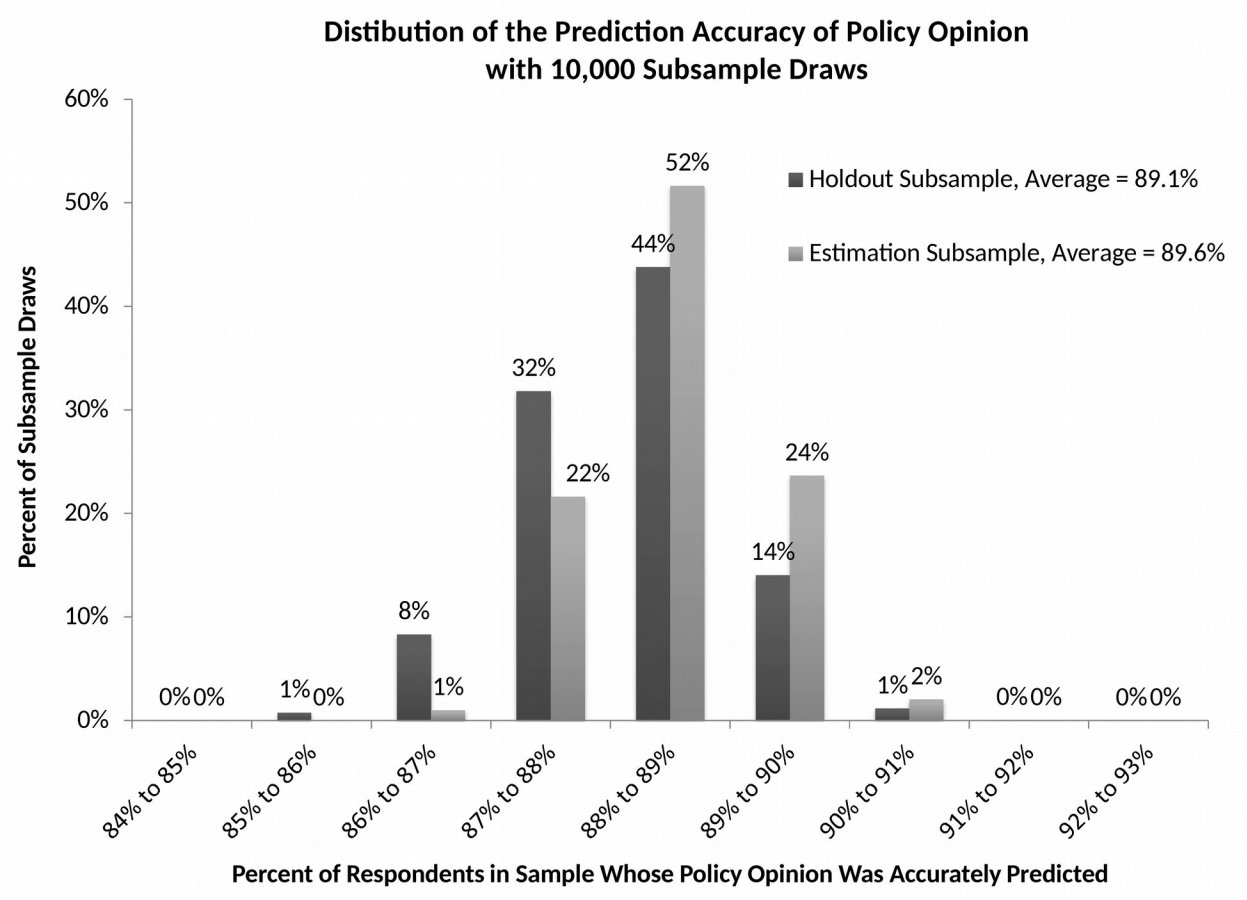
Among the factor coefficients, the coefficients attached to respondent ethnicity were all positive and nearly all statistically significant. This means that the relative magnitude of the coefficients distinguishes which ethnic groups are likely to be more supportive. Finally, the politics coefficients were found to be statistically significant for those on opposite ends of the political spectrum. The coefficient for “very liberal” is positive, while the coefficient for “very conservative” is negative, and both are significant. Those expressing more moderate political views were of the expected sign but not significant.

6. Ordinal Regression Model Performance and Accuracy Validation

The model presented above identifies variables that most influence feebate policy support. However, evaluating model performance requires additional steps. To do this, we calculate the model’s ability to correctly re-predict the support or opposition of individual respondents in the complete estimation sample, which for the full sample was 89.4% accuracy. Here, we take this further and evaluate how the model performs when estimated under the same formula structure with a randomly drawn subsample (termed “estimation subsample”). The model estimated using the subsample is then used to predict policy support or opposition of the remaining respondents not selected as part of the estimation subsample (termed “holdout subsample”). The accuracy of this prediction shows how well the model performs using the coefficients estimated from one subsample and predicting the policy opinions of an independent subsample. We repeated this procedure 10,000 times, each time splitting the sample in half by drawing a new n=1,236 estimation subsample and using it to predict the policy opinions of the remaining n=1,237

holdout subsample. We present results that characterize the distribution of prediction accuracy across all draws for both subsamples in Figure 2.

Figure 2 Distribution of Prediction Accuracy of Policy Opinion with 10,000 Subsample Draws



The accuracy of predicting the holdout subsample (darker bars) is most important because data from these respondents are not used to inform the model coefficients. The other (lighter) distribution characterizes the accuracy of the model re-predicting the policy opinions of those respondents used to generate the model. The holdout accuracy distribution shows lower prediction accuracy than the estimation accuracy distribution, an expected result. But remarkably, both distributions are relatively tight and maintain high accuracy, a promising result for evaluating the opinions of broader populations using this model.

In addition to accuracy, we evaluate the distribution of coefficient values that are generated by each subsample. This is useful for evaluating the stability of the coefficients from which we drew insights in the previous section. Table 4 shows the structure of the model as presented Table 3 with the full model coefficient values alongside five parameters that characterize the distribution of coefficients estimated from the subsample. For each coefficient, the minimum, maximum,

median, 2.5% percentile, and 97.5% percentile values from the 10,000 model estimations are given.

Table 4 Distribution Parameters of Subsample Estimated Coefficients

Dependent Variable Threshold Coefficients		Full Model Coefficient	Subsample Min	Subsample 2.5%	Subsample Median	Subsample 97.5%	Subsample Max
Strongly Disagree | Disagree		1.903	-0.09	0.86	1.91	2.96	4.06
Disagree | Agree		3.570	1.73	2.61	3.61	4.66	5.72
Agree | Strongly Agree		5.871	4.33	4.99	5.98	7.04	8.14
Covariate Variables		**Full Model Coefficient**	**Subsample Min**	**Subsample 2.5%**	**Subsample Median**	**Subsample 97.5%**	**Subsample Max**
Global warming is happening		0.443	0.16	0.29	0.45	0.61	0.72
Humans cause global warming		0.400	0.12	0.24	0.41	0.58	0.68
Foreign oil dependence is a problem		0.129	-0.15	0.00	0.13	0.25	0.40
Education		0.025	-0.08	-0.03	0.02	0.07	0.12
Income		-0.073	-0.15	-0.12	-0.07	-0.03	0.02
Age		0.019	-0.15	-0.05	0.02	0.09	0.13
MaxFuelEconomy		0.009	-0.02	-0.01	0.01	0.02	0.04
Feebates is a fair policy		0.792	0.60	0.70	0.83	0.99	1.18
Feebates is an unfair policy		-0.294	-0.60	-0.45	-0.31	-0.18	-0.08
Number of kids 18 and under		0.038	-0.12	-0.04	0.04	0.11	0.18
Factor Variables		**Full Model Coefficient**	**Subsample Min**	**Subsample 2.5%**	**Subsample Median**	**Subsample 97.5%**	**Subsample Max**
Race or Ethnicity	Caucasian	0.425	-0.34	0.04	0.43	0.84	1.27
	Hispanic	0.771	0.00	0.38	0.79	1.23	1.73
	African American	0.463	-0.42	0.02	0.48	0.95	1.37
	Asian	0.533	-0.31	0.10	0.54	1.00	1.39
	Native American	0.492	-0.61	-0.01	0.51	1.04	1.56
	Pacific Islander	0.480	-1.41	-0.33	0.49	1.22	1.97
	Other	0.547	-0.72	-0.08	0.56	1.18	1.77
Political Alignment	Very Liberal	0.450	-0.57	-0.07	0.45	1.03	1.64
	Liberal	0.275	-0.72	-0.19	0.27	0.79	1.31
	Moderate	0.123	-0.76	-0.35	0.11	0.63	1.16
	Conservative	-0.098	-1.13	-0.60	-0.11	0.41	0.96
	Very Conservative	-0.492	-1.63	-1.09	-0.51	0.10	0.74
	Other	-0.158	-1.78	-0.84	-0.17	0.48	1.37
	Not Sure	0.356	-1.42	-0.45	0.33	1.04	1.74

The median values of the subsample distribution are consistently close to the full model coefficients. The parameters defining the spread of estimated values show stability across the key variables that drive the insights from the model. For example, all estimates show that acknowledgement of global warming, as well as belief of anthropogenic contributions to it, increase feebate support. Table 4 also indicates that at least 97.5% of coefficient estimates for income were of negative value. Perceived fairness and unfairness of the policy were found to be positive and negative, respectively, for all subsample draws. A wider variation in coefficient values exists with the factor variables. Political variables were influential directionally as expected; meanwhile, most race/ethnicity factors exhibited distributions on balance greater than zero. Broadly, Table 4 shows that the coefficients of key variables exhibited a general stability in value and sign even when derived from numerous subsamples half as large as the complete sample.

7. Conclusion

This study explored the public perception of California residents to a proposed feebate policy using focus groups and statewide survey. We explored public perception from an empirical perspective and evaluated model robustness for predicting public perception across the population by identifying the key factors that correlate with support or opposition. Empirically, the survey found that most people (~76%) were supportive of the feebates concept to lower GHG emissions, and roughly one-in-five (~22%) were opposed to the policy. Feebate opposition was found to be associated with skepticism about the seriousness of climate change and its links to human activity, conservative political views, ownership of less efficient vehicles, and higher income. The ordinal regression model also found the perception of policy fairness (and unfairness) were strong predictors of policy position. Identifying the key variables influencing feebate policy position, while controlling for the influence of all other variables, was a critical benefit of applying the ordinal regression model to this data.

The model exhibited very good accuracy in re-predicting feebate policy position of the entire sample. This was taken a step further in evaluating how a large number of models estimated from randomly drawn subsamples would perform in predicting the response within holdout samples. The performance was also very good, as these models could predict the responses of the other sample half with nearly the same accuracy (~90%). Methodologically, this illustrates a simple approach for validating such models when samples are large enough. It also shows an application of ordinal regression for predicting policy position on this and other public policy issues with further refinement.

The focus group results complement the survey findings with respect to perceived fairness. Each suggests that with further consideration, public opinion could change with greater exposure to the feebates concept. This change could be in either direction but may hinge on the perception of climate change and policy fairness. Differences in the focus group (which were more negative towards feebates) and the survey response suggest some influential dynamics. In particular, the intimate and in-depth nature of focus groups often induces a more critical discourse, as vocal critics dominate and sway reticent supporters or undecided participants. The survey, on the other

hand, permits people to opine independently. These considerations are important for evaluating the future prospects of a support for a policy such as feebates on new vehicles.

Overall, the results showed that a majority level of support existed for a general type of feebate policy in California at the time of survey. Furthermore, feebate policy support cut across all key demographic attributes within the sample. The results suggest that feebate policy designs that effectively balance program objectives with "fairness" considerations will likely exhibit greater initial and enduring support with the public overall. Also additional efforts to educate the public about the potential seriousness of climate change and linkages to human activity may also have a positive impact on support for vehicle feebate policies.

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