Not all subsidies are equal: measuring preferences for electric vehicle financial incentives

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Keywords: electric vehicles, subsidies, consumer preferences, conjoint analysis, discrete choice

1. Introduction

Plug-in electric vehicles (PEVs) are an important pathway for decarbonizing the transportation sector, yet sales in the U.S. are still relatively low. Federal and state incentives, such as purchase subsidies, have been shown to have a measurable effect on increasing PEV adoption [1], but how these incentives are designed can affect their effectiveness as well as how equitably they are distributed. Using a national conjoint survey (N = 2170 respondents), we quantify how U.S. vehicle buyers value different features of PEV financial incentives. Participants overwhelmingly prefer immediate rebates, on average valuing them by $580, $1450, and $2630 more than sales tax exemptions, tax credits, or tax deductions, respectively. These effects are significantly larger for lower-income households, used vehicle buyers, and buyers with lower budgets. We estimate that on average $2 billion could have been saved if the federal subsidy available between 2011 and 2019 were delivered as an immediate rebate instead of a tax credit, or $1440 per PEV sold. Our results suggest that structuring incentives as immediate rebates would deliver a greater value to customers and would be more equitably distributed compared to the current tax credit scheme.

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These results are consistent with the well-known phenomenon of ‘present bias,’ a cognitive bias in which money is valued more in the present than in the future [9].

Incentive design also impacts how equitably incentives are distributed. In a review of the distributional effects of U.S. clean energy tax credits, Borenstein and Davis found that incentive programs aimed at incentivizing PEV purchases were the most extreme in terms of the incentive distribution, with the top income quintile receiving approximately 90% of all credits [10]. This outcome is unsurprising considering how the federal subsidy tax credit is structured. In general, time-delayed incentives like tax credits are skewed towards higher-income buyers who can afford the full up-front PEV purchase price. Furthermore, not all households are eligible to receive the full PEV incentive amount ($7500 for most full electric vehicles) as it depends on tax liability. Specifically, households with lower tax liabilities due to income or the availability of other credits, such as the child tax credit, may not receive the full credit amount compared to high-income earners with larger tax liabilities.

In a study on Atlanta, GA, researchers estimate that only 23%–45% of the city population could qualify for the full PEV tax credit, and these percentages are even lower for minority populations [2].

Finally, while the vast majority of PEV tax credits have gone to the wealthiest buyers [11], studies suggest that a more equitable allocation to buyers with lower and middle incomes may have been more effective at increasing overall PEV adoption. A survey by Hardman and Tal found that financial incentives were not an important decision factor for purchasers of high-end PEVs but were significantly important for purchasers of lower-end PEVs [12]. Likewise, in a quasi-experimental analysis of subsidies in California, Muehlelegger and Rapson found relatively large demand elasticities for PEVs among low-income buyers, with an estimated 32%–34% increase in demand for every 10% reduction in purchase price via a subsidy [13]. The combined outcomes of these prior studies suggest that improvements could be made to incentive designs to make them more attractive and equitable.

2. Method

We aimed to measure how U.S. vehicle buyers value different features of PEV financial incentives to identify incentive designs that are both more valuable to consumers and more likely to be distributed across a more diverse group of consumers. To do so, we designed and fielded a nationwide choice-based conjoint survey online in August and September of 2021. In conjoint surveys, respondents are asked to choose their most preferred option from a set of alternatives in a series of consecutive choice questions. Each alternative in each choice question is comprised of a list of attributes (e.g. ‘price’) with different levels (e.g. different dollar amounts). We use a randomized survey design, meaning that the attribute levels shown in each choice set were randomly chosen from the full set of combinations of all the levels for each attribute. While this approach requires a larger sample size to obtain precise parameter estimates compared to alternatives that attempt to maximize information, such as ‘D-optimal’ designs, it allows for greater flexibility in the types of models that can be estimated [14]. The choice data obtained can then be used to estimate choice models to quantify the relative value respondents hold for each attribute shown.

By using a controlled experiment, we are able to disaggregate preferences for different incentive features and explore heterogeneity in those preferences among different sub-populations, which can be difficult (if not impossible) using historical incentive data as they have limited variation amongst incentive features. Furthermore, our survey results reveal preferences for the general car buying population as opposed to wealthy early adopters. Given the diversity of car buyers in our sample, we report effects for different subgroups in the sample, which is important for any revisions to current subsidy policy as PEVs are gradually adopted by more diverse populations.

We restricted the survey to financial incentives because these incentives have been found to be one of the more effective types [1] and because including other non-financial incentives would require a substantially larger sample size to identify the preferences of sub-groups within the sample, which is important for understanding the equity implications of the study. Based on preliminary piloting and reviews of prior literature, the following incentives features were included in the choice questions: (a) Type—a tax credit, tax deduction, sales tax exemption, or a direct rebate; (b) Amount—the total dollar amount of the incentive, ranging from $1000 to $8000 in increments of $500, which reflects the range of historically available incentive amounts (for the sales tax type, the amount is an exemption of 50%, 75%, or 100% of the sales tax, computed as the participants self-reported budget multiplied by 7.5%); (c) Timing—the time when the incentive will be received (immediately versus several levels of delay, ranging from weeks to the next tax filing period); and (d) Source—the government, dealership, or original equipment manufacturer (OEM). Each participant answered ten consecutive conjoint questions. We also asked additional questions regarding respondent demographics as well as their knowledge about and experience with PEVs. Respondents were screened such that they were 18 years old or older, reside in the U.S., and were in the market for a vehicle. The full text of the survey is available in the supplementary information.

To ensure that participants understood the choice task, respondents were first shown a practice question where the rebate option was the logically dominant
choice. This question was used to screen out respondents as choosing anything other than the dominant choice suggests they were likely either not paying close attention or did not understand the choice task. Figure 1 shows example choice questions.

The conjoint choice questions were designed and randomized using the 
\texttt{cbcTools} R package \cite{15}, and the survey was implemented on \texttt{formr.org}, an open-source online platform that uses the R programming language to define survey questions \cite{16}. An initial pilot survey was fielded on Amazon Mechanical Turk (\(N = 216\) participants) for basic testing purposes. The final survey was fielded using an online panel via Dynata, a market research firm. We applied a stratified sampling approach to match the income distribution of U.S. car buyers for the first 2000 respondents, and we collected an additional 500 respondents targeting those with household incomes below $50,000 as this group was under-sampled in the original run. We accounted for cost of living (COL) differences across the national sample by adjusting the \textit{amount} variable shown in the survey by a COL adjustment scalar prior to estimating all models. The COL scalar for each respondent was obtained by matching each respondent’s self-reported zip code to its associated core-based statistical area (CBSA) using data from the U.S. Department of Housing and Urban Development \cite{17} and then matching each CBSA to a COL adjustment factor from the real personal income by State and Metropolitan Area dataset provided by the U.S. Bureau of Economic Analysis \cite{18}. This resulted in the \textit{amount} value being scaled down by a factor less than 1 in locations where the COL is higher than the national average (since the value of a dollar buys less in places with a higher COL) and scaled up by a factor greater than 1 where the COL is lower than the national average. This COL adjustment had little effect on the model results (see table A4 in the supplementary information for the un-scaled model results). After removing 338 respondents who did not have a zip code that matched with the COL adjustment data, our final sample was 2170 respondents. Table 1 summarizes demographic statistics of the final sample including COL adjusted results.

Using the choice data, consumer choice can be modeled using a random utility framework, which assumes that individual consumer \(i\) makes choices among alternatives \(j\) that maximize an underlying random utility model, \(u_{ij}\), which can be parameterized as a function of an alternative’s

\begin{table}[h]
\centering
\caption{Summary of sample demographics.}
\begin{tabular}{ll}
\hline
Summary statistics & \(N = 2170\) \\
\hline
\multicolumn{2}{l}{Age} \\
Min & 19 \\
Max & 92 \\
Mean & 56 \\
(NA) & 6 \\
\hline
\multicolumn{2}{l}{Gender identity} \\
Male & 1211 (56\%) \\
Female & 942 (43\%) \\
Other & 11 (0.5\%) \\
Prefer not to say & 2 (<0.1\%) \\
(NA) & 4 \\
\hline
\multicolumn{2}{l}{Timeframe for purchase} \\
1 year & 914 (42\%) \\
0–3 months & 786 (36\%) \\
No timeline & 470 (22\%) \\
\hline
\multicolumn{2}{l}{Shopping for new or used} \\
New & 1284 (59\%) \\
Used/both/not sure & 886 (41\%) \\
\hline
\multicolumn{2}{l}{Income} \\
>Median & 1404 (65\%) \\
<Median & 750 (35\%) \\
Prefer not to say & 12 (0.6\%) \\
(NA) & 4 (0.15\%) \\
\hline
\end{tabular}
\end{table}
observed attributes, $v_{ij}$, and a random variable representing the portion of utility that is unobservable to the modeler, $\varepsilon_{ij}$, such that $u_{ij} = v_{ij} + \varepsilon_{ij}$. For this study, the utility model for alternative $j$ for individual $i$ can be expressed as follows:

$$u_{ij} = \beta' x_j - \lambda a_j + \varepsilon_{ij},$$

where $\lambda$ is the coefficient for the incentive amount, $a_j$, and $\beta$ is a vector of coefficients for all other attributes, $x_j$. To make the results more easily interpretable, we specify the utility model in the ‘willingness-to-pay’ (WTP) space [19, 20] such that estimated model coefficients represent the marginal WTP (or valuation in the context of this study) for marginal changes in each attribute:

$$u_{ij} = \lambda (\omega' x_j - a_j) + \varepsilon_{ij},$$

where $\omega$ is the WTP coefficients for all non-price attributes, $x_j$, and $\lambda$ is now a scale parameter. Using the WTP space for the utility models has several conveniences. Since WTP coefficients have units of dollars, they can be immediately interpreted and understood independent of other parameters. In addition, since WTPs are independent of error scaling, they can be directly compared across different models estimated on different subsets of the data. In contrast, preference space coefficients represent marginal utility, which must be interpreted relative to other parameters and cannot be directly compared across models due to potential scaling differences. For the specific context of this study, the general WTP space utility model takes the following form:

$$u_{ij} = \lambda \left( \omega' x_j + \tau' x_j^{\text{timing}} + \eta' x_j^{\text{source}} + \omega^{\text{type}}' x_j^{\text{type}} + \omega^{\text{timing}}' x_j^{\text{timing}} + \omega^{\text{source}}' x_j^{\text{source}} - a_j \right) + \varepsilon_{ij},$$

where $\omega$, $\tau$, and $\eta$ are vectors of WTP parameters for each incentive type, timing, and source, respectively, and each of the $x_j$ terms are the dummy-coded variables for these respective attributes. The incentives amount is given by $a_j$. Interactions terms for type $^{\text{timing}}$ and type $^{\text{source}}$ are included since the timing and source values vary depending on the type (e.g. the sales tax exemption is always at the time of sale). The rebate type was set as the reference level for the dummy-coded incentive types. For timing, the reference level was time of sale for the tax credit and rebate types (the timing did not vary for the sales tax and tax deduction types). Finally, for source, the reference level was government for the rebate type (the source did not vary for all other incentive types).

We assess consumer valuation for different financial incentive features by estimating multinomial logit (MNL) models on the full sample and subgroups within the sample as well as a mixed logit (MXL) model on the full sample via maximum likelihood estimation, a common and well-established estimation approach for discrete outcome utility models [21, 22]. The MNL models assume fixed preference parameters across the survey population whereas in the MXL model preference heterogeneity is modeled according to parametric assumptions about the population preference parameters. One of the convenient features of the logit model is that by assuming the error term of the utility model follows a Gumbel extreme value distribution, the probability that a consumer $i$ will choose option $j$ from the choice set $I_i$ follows a convenient closed form expression [22]:

$$P_{ij} = \frac{\exp(v_i)}{\sum_{k \in I_i} \exp(v_k)}, \quad \forall c \in \{1, 2, 3 \ldots C\}, \quad j \in I_i,$$

where $c$ indexes a set of $C$ choice sets. For MXL, probabilities are approximated using random draws from parameter distribution via maximum simulated likelihood [22]. Panel effects from repeated choices by each individual are accounted for in the calculation of the log-likelihood function for MXL models (see equation (6.2) in Train [22]), and standard errors are clustered at the individual level. All models were estimated using the logitr R package [23].

Finally, in our results we present some WTP values as the sum of multiple different WTP coefficients. For example, the WTP for a 6 week-delayed rebate from a dealership is the sum of the coefficients. For example, the WTP for a 6 week-delayed rebate (e.g. the sales tax exemption is always at the time of sale). The rebate type was set as the reference level for the dummy-coded incentive types. For timing, the reference level was time of sale for the tax credit and rebate types (the timing did not vary for the sales tax and tax deduction types). Finally, for source, the reference level was government for the rebate type (the source did not vary for all other incentive types).

3. Results

We present the results from several models. Model 1 is a MNL of the full sample, model 2 is a MXL of the full sample, and models 3–5 are MNL models on subgroups based on demographic information, including high- vs. low-income buyers (3), new vs. used vehicle buyers (4), and high vs. low budgets (5). All models are estimated in the ‘Willingness to Pay’ (WTP) space such that coefficients reflect preference values in dollars [19, 20]. Table 2 shows the estimated coefficients from each model, which are in units of thousands of dollars. Since each respondent answered ten choice questions, the final dataset includes 21 700 choice observations from sets of four incentive types: sales tax exemption, tax credit, tax deduction, and rebate.

Results from all models suggest that car buyers value financial incentives significantly differently.
Table 2. Summary of estimated model coefficients.

| Model: | MNL | MXL | Above median income | Below median income | New car buyers | Used car buyers | Budget >$30k | Budget <$30k |
|--------|-----|-----|---------------------|---------------------|----------------|----------------|--------------|--------------|
|        | (Mean) | (St. dev) |                    |                     |                |                |              |              |
| Respondents: | N = 2170 | N = 2170 | N = 1404 | N = 750 | N = 1284 | N = 886 | N = 1125 | N = 1045 |
| Scale parameter* | 0.519 *** | 0.711 *** | — | 0.562 *** | 0.460 *** | 0.525 *** | 0.512 *** | 0.545 *** | 0.488 *** |
| (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) | (0.0) |
| Sales tax | −0.582 *** | −0.648 *** | 2.235 *** | −0.499 *** | −0.742 *** | −0.586 *** | −0.563 *** | −0.389 *** | −0.858 *** |
| (0.1) | (0.1) | (0.1) | (0.1) | (0.2) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) |
| Tax credit | −1.449 *** | −1.583 *** | 2.508 *** | −0.982 *** | −2.438 *** | −1.143 *** | −1.896 *** | −0.973 *** | −1.963 *** |
| (0.1) | (0.1) | (0.1) | (0.1) | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) |
| Tax deduction | −2.727 *** | −3.576 *** | −2.800 *** | −2.436 *** | −3.261 *** | −2.726 *** | −2.718 *** | −2.443 *** | −3.048 *** |
| (0.1) | (0.1) | (0.1) | (0.1) | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) |
| Tax credit: immediate | 0.403 *** | 0.297 ** | −0.365. | 0.239 ** | 0.789 *** | 0.140 | 0.798 *** | 0.198 * | 0.624 *** |
| (0.1) | (0.1) | (0.2) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) |
| Rebate: 2 week delay | −0.075 | −0.026 | 0.344 | −0.016 | −0.190 | −0.081 | −0.063 | −0.000 | −0.156 |
| (0.1) | (0.1) | (0.2) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) |
| Rebate: 6 week delay | −0.318 *** | −0.254 *** | 0.492 ** | −0.231 * | −0.510 *** | −0.352 *** | −0.273 * | −0.143 | −0.515 *** |
| (0.1) | (0.1) | (0.2) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) |
| Rebate: source OEM | −0.022 | −0.148. | −0.574 *** | −0.011 | −0.014 | −0.050 | 0.025 | 0.008 | −0.057 |
| (0.1) | (0.1) | (0.2) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) |
| Rebate: source dealer | −0.042 | −0.102 | −0.323 * | 0.012 | −0.124 | −0.112 | 0.057 | −0.012 | −0.079 |
| (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) |

Signif. Codes: *** = 0.001, ** = 0.01, * = 0.05, = 0.1, = 1.

* The incentive amount in all models was scaled to account for cost-of-living differences.
depending on how they are implemented. Coefficients from model 1 imply that participants overwhelmingly prefer immediate rebates, on average valuing them by $580, $1450, and $2630 more than sales tax exemptions, tax credits, or tax deductions, respectively (see figure 2). The MXL model (model 2) suggests similar results, valuing immediate rebates by $650, $1580, and $3580 more than sales tax exemptions, tax credits, or tax deductions, respectively. The results that a sales tax exemption is valued at several hundred dollars less than an immediate rebate is particularly interesting as they both occur at the time of sale, suggesting there could be an intrinsic difference in value for receiving money compared to avoiding a fee. In addition, unlike an immediate rebate, the dollar savings from a sales tax exemption can depend on the purchase price.

The current federal tax credit was consistently one of the least-valued incentives, with an average devaluation of $1450 (model 1) and $1580 (model 2) compared to an immediate rebate. Even after adjusting the tax credit timing to be assignable at the point of sale, it is still over $1000 less valuable to consumers compared to an immediate rebate. While this may seem surprising, it is important to again emphasize that many households may not be able to claim the full tax credit as it depends on their tax liability. In contrast, the direct rebate is immediately delivered, reducing the purchase price, taxes, and fees at the point of sale, and the amount provided is independent of any individual’s tax circumstances.

Our results also indicate that the timing of when an incentive is received matters, with delays resulting in significant devaluations. For example, model 1 suggests that delaying a rebate by 2 weeks or 6 weeks lowers the incentive value by approximately $40 or $320, respectively. Using these results, we can compute the implied discount rate of the current maximum federal tax credit ($7500) for different incentive types. Using coefficients from model 1 suggests that car buyers discount time-delayed incentives at rather large rates: 30%, 46%, and 54% for 2 week, 6 week, and 6 month delays, respectively. These rates are consistent with depreciation rates of passenger vehicles; for example, gasoline-powered vehicles typically lose as much as 60% of their initial value within their first five years of use, which is equivalent to a 20% discount rate [25]. These discount rates suggest that delaying incentives can significantly reduce their value to consumers.

Given that the vast majority of historical PEV subsidies have been allocated to wealthier car buyers [10, 11], making PEV incentives more equitably accessible is critically important for the design of future incentive policies. We compared the preferences of respondents from households with annual incomes above and below the median U.S. income (model 3), which is $67,521 according to the 2020 census [26], those who stated they were shopping exclusively for new vehicles versus those that were also considering used vehicles (model 4), and those with larger versus smaller stated budgets (model 5). Results show that an immediate rebate is even more highly valued for lower-income buyers, used vehicle buyers, and those with smaller budgets. Specifically, respondents with annual household incomes below
the median income ($N = 750$) valued a tax credit by $2440 less than an immediate rebate whereas those with annual household incomes above the median ($N = 1404$) valued a tax credit by $1000 less than an immediate rebate (see figure 3). Below-median income households also devalued the tax deduction and sales tax exemption incentives at greater levels than higher-income households. Similarly, used vehicle buyers ($N = 886$) valued a tax credit at $1900 less than an immediate rebate compared to only $1140 for new car buyers ($N = 1284$), and respondents with a budget of less than $30,000 ($N = 1045$) valued the tax credit at $1960 less than an immediate rebate compared to only $970 for those with higher budgets ($N = 1125$). Preferences for other incentive features were similar for each of these groups.

In addition, participants were asked whether they knew the current maximum federal tax credit, whether or not they would ever consider purchasing a battery electric vehicle (BEV) or plug-in hybrid vehicle (PHEV), and whether or not their neighbors own a PEV (response summaries are shown in table 3). Results from models comparing groups according to their responses to these questions (table A6 in the supplementary information) suggest that the tax credit design is less attractive to buyers who are already less likely to purchase a PEV. Likewise, those who are already considering a PEV, know more about the current incentives, and have neighbors that own a PEV value those incentives more. All of these groups strongly preferred an immediate rebate over the current tax credit system. These results also suggest that improving education and awareness about PEVs and available incentives may be important for increasing the value of future incentives to customers as those who were more knowledgeable about PEVs valued the incentives more. Results of models estimated comparing other demographic groups largely had insignificant statistical differences between groups, often due to small sample sizes in one or more group. These include housing ownership, access to home parking, ethnicity, education, and work.

Across every model we estimated, immediate rebates were valued significantly more than tax credits. This suggests that the federal government could have achieved the same value to PEV buyers with less taxpayer dollars if the federal PEV subsidy had been implemented as an immediate rebate. To estimate this potential savings, we estimated the total amount of federal tax credits available to all eligible PEVs sold between 2010 and 2019 (approximately 1.4 million PEVs) [27, 28]. Using PEV sales data at the make-model level, we assumed that BEVs received the full tax credit amount ($7500) and computed the amount for PHEVs based on the battery capacity, accounting for the subsidy phase out when specific models that reached the 200,000 sales limit [29]. This results in an estimated $8.65 billion in tax credits. If this subsidy were instead implemented as an immediate rebate, we estimate the federal government could have saved approximately $2.07 billion (24%), or $1440 per PEV on average (see figure 4). This implies that an immediate rebate program would still deliver greater value to customers at the same cost to the government.

![Figure 3](https://i.imgur.com/3.png)

**Figure 3.** Value of different incentive designs relative to an immediate government rebate at the time of sale for above- and below-median income households. Bars represent the mean WTP coefficients from model 3, and error bars reflect a 95% confidence interval computed via simulation as described in section 2 [24].
so long as the potential additional administrative burden of implementing the program remains less than $1440 per PEV.

4. Discussion

In this study, we aimed to understand how consumers value different features of PEV incentives to inform the development of a more effective and equitable incentive design. Based on the results of a nationwide conjoint survey, we find that both the incentive type (tax credit, tax deduction, sales tax exemption, or direct rebate) and timing (at the point of sale or some period after purchase) significantly impacted its value while the source (government, dealer, or OEM) had little to no impact. Respondents valued more immediate incentives over time-delayed incentives, with discount rates ranging from 30% to 53% for

**Table 3.** Response summary for PEV-related questions.

| Do you know the current maximum available federal subsidy? | Would you ever consider purchasing a PHEV? |
|------------------------------------------------------------|------------------------------------------|
| Not sure                                                   | Definitely yes                           |
| $10,000                                                   | Probably yes                             |
| $7,500                                                    | Maybe/not sure                           |
| $5,000                                                    | Probably not                             |
| $2,500                                                    | Definitely not                           |
| $1,000                                                    | (NA)                                      |
| (NA)                                                      | 3                                         |

| Do any of your neighbors own a PEV? | Would you ever consider purchasing a BEV? |
|------------------------------------|------------------------------------------|
| Yes                                | Definitely yes                           |
| No                                 | Probably yes                             |
| Not sure                           | Maybe/not sure                           |
| (NA)                               | (NA)                                      |
|                                    | 3                                         |

**Figure 4.** Estimated annual federal PEV subsidy allocation between 2011 and 2019. The red portion indicates the estimated amount the federal government could have saved if the tax credit were delivered as an immediate rebate rather than a tax credit. Estimates are based on applying the federal tax credit policy to every eligible PEV sold using sales data from hybridcars.com and insideEVs.com.
time-delayed incentives. Immediate rebates delivered at the time of sale are the most-valued incentive design across all subgroups in our sample. Relative to the current federal tax credit incentive, immediate rebates are valued by as much as a $1450 more on average. These findings are consistent with prior research that suggests consumers prefer incentives that are applied at the point of sale over those applied post-sale [1, 8].

Research has also shown that the current tax credit strongly favors households with higher incomes and fewer children and is thus not equitably accessible [2]. Our results complement these findings and suggest that the valuation for immediate rebates is nearly twice as large for lower-income households compared to higher-income households and approximately 50% larger for used vehicle buyers compared to new vehicle buyers. This suggests that implementing the PEV subsidy as a direct rebate and extending it to used PEVs could be an effective strategy to encourage a more equitable adoption of PEVs.

Our results also suggest that improving education and awareness about PEVs may also increase the incentive value to potential PEV buyers; approximately 85% of participants who took our survey could not correctly identify the currently maximum federal subsidy amount for PEVs, and respondents that lacked this knowledge or were not considering purchasing a PEV valued the tax credit less. This is consistent with other research that suggests direct experience with PEVs can increase consumers' willingness to consider purchasing them [30]. Combining an education and awareness campaign along with changes to incentive policy that aligns with consumer preferences could result in a more effective and equitable incentive by a larger and more diverse population than today's tax credit.

Unfortunately, the structure of today's PEV subsidy—a tax credit delivered when filing taxes—was consistently one of the least-valued incentive types, with only a tax deduction being valued less. This finding is not necessarily surprising considering the inconveniences and hurdles associated with the tax credit design. First, if the taxes a PEV buyer owes are less than the maximum $7500 credit, the buyer will not receive the excess amount. Furthermore, since the credit is delayed until the annual tax filing process, the PEV buyer must finance the full PEV purchase price along with any state sales taxes and fees evaluated at that price. These two factors can significantly reduce the total amount of incentive available to consumers.

Nonetheless, maximizing value to the customer may not be a prioritized objective when designing a PEV incentives; indeed, ease of implementation can often outweigh other factors. For example, including a new tax credit into the already well-established tax filing procedure is arguably a simpler system to adopt (and pass legislation for) than many other alternative designs. Furthermore, the current implementation of the tax credit does not necessarily require the government to send funds to buyers but rather reduces the total tax revenue raised. As a result, overhead costs for implementing the tax credit are potentially lower than alternative designs.

Based on the consumer preferences from our experiment, we estimate that by delivering the federal PEV subsidy as a tax credit, the cumulative amount of subsidy available to prior PEV purchases was devalued by approximately 24% compared to if it were delivered as an immediate rebate, resulting in a loss in value to customers (or a potential savings to the government) of $2.07 billion. While an immediate rebate may incur higher administrative costs to deliver compared to a tax credit, it would result in a more equitably distributed subsidy and would deliver a greater value to customers, and it would still be at least as cost effective as the current tax credit design so long as additional administrative burdens are no greater than $1440 per PEV.

5. Conclusions

Despite their rapid growth in countries with more aggressive policies [31], PEVs comprise just 2%–3% of the new vehicle market share in the U.S. [28]. If the U.S. is to catch up with other countries, PEV incentives will play an important role, especially in expanding PEV adoption to more diverse populations beyond wealthy early adopters. How these incentives are designed can affect both their effectiveness and accessibility to diverse populations.

In this study, we aimed to understand how consumers value different features of PEV incentives to inform the development of a more effective and equitable incentive design. Based on the results of a nationwide conjoint survey, we found that an immediate rebate delivered at the time of sale is the most-valued incentive design across all subgroups in our sample. Relative to the current federal tax credit incentive, immediate rebates are valued by as much a $1450 more on average, and this valuation is nearly twice as large for lower-income households compared to higher-income households. We also found that used vehicle buyers value an immediate rebate more than new vehicle buyers. Implementing a direct rebate for both new and used PEVs could be an effective strategy to encourage a more equitable adoption of PEVs.

We also estimate that by delivering the federal PEV subsidy as a tax credit, the cumulative amount of subsidy available to prior PEV purchases was devalued by approximately 24% compared to if it were delivered as an immediate rebate, resulting in a loss of $2.07 billion in value to customers or savings to the government ($1440 per PEV sold on average). While an immediate rebate may incur higher administrative costs to deliver compared to a tax credit, it would result in a more equitably distributed subsidy and would
deliver a greater value to customers. Finally, our results suggest that improving education and awareness about PEVs may also increase the incentive value to potential PEV buyers.

Data availability statement

The data that support the findings of this study are openly available at the following DOI: 10.5281/zenodo.6807674 [32].

Acknowledgments

The authors would like to thank the International EV Policy Council, whose 2020 meeting inspired the concept for this project. This research was supported by the Energy and Environment program at the Alfred P. Sloan Foundation.

Ethical statement

All participants in this research were 18 years or older and consented to participate in this study. This research was determined to be research that is exempt from IRB review under DHHS regulatory category 3 by the George Washington University IRB (#NCR213531).

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