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Impact of the Clean Vehicle Rebate Project's increased rebates for low- and moderate-income individuals on California's ZEV Market

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ABSTRACT

This paper reviews and summarizes the research regarding California's Clean Vehicle Rebate Project's (CVRP) implementation of increased rebates for low- and moderate-income recipients in March 2016 and increase of these rebates in November 2016. Due to the recent nature of the program, no peer-reviewed research has been published about the specific effects of CVRP. Yet some research explores the effects of rebates for low- and moderate-income individuals as part of other programs, such as the Enhanced Fleet Modernization Program (EFMP). Consequently, we review the literature evaluating past and present programs with similar policy features as well as survey-based research that takes a stated-preference approach.

Research indicates that incentives have largely accrued to higher-income households and individuals, raising concerns about inequitable[1] incentive distribution. There may be related cost-effectiveness concerns if wealthy households would have purchased zero-emission vehicles (ZEV) in the absence of a subsidy. While we are limited in determining the specific effects of CVRP's increased rebates, the literature suggests that rebates are a significant factor in the purchase decisions of low- and moderate-income individuals, as the purchase price of a ZEV is typically much higher than the purchase price of a traditional vehicle.

This whitepaper includes recommendations for future research to identify the specific impacts of CVRP's increased rebates.

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[1] Inequitable in the context of CVRP incentives primarily refers to income inequality. If 50% of incentives are realized by those in the top 20% of the income distribution, then the incentives are inequitable.

1 Purpose

Assembly Bill (AB) 615 requires the California Air Resources Board (CARB) to "prepare and submit to the Legislature a report on the impact of the Clean Vehicle Rebate Project on the state's zero-emission vehicle market...The report shall include, but is not limited to, the impact of income caps, increased rebates for low-income consumers, and increased outreach on the electric vehicle market." This whitepaper supports CARB in fulfilling AB 615's mandate by assessing the impact of California's Clean Vehicle Rebate Project (CVRP) implementation of increased rebates for low- and moderate-income recipients in March 2016 and increase of these rebates in November 2016. The assessment is based on a review of literature related to zero-emission vehicle (ZEV) incentive programs, including general findings, research gaps, and policy implications of both.

2 Policy description

California is a leader on combating climate change. The state has set bold goals of reducing statewide greenhouse gas (GHG) emissions to 80% below 1990 levels by 2050, as well of achieving 5 million ZEVs on the road by 2030. Reaching these goals will require effective policies and programs, as well as periodic assessment of both. A key state effort to incentivize ZEV adoption, and thus reduce emissions from the light-duty transportation sector, is the Clean Vehicle Rebate Program (CVRP).

The CVRP was created by AB 118 in 2007 to incentivize ZEV purchasing and leasing. The CVRP's primary purpose is to support widespread commercialization of the cleanest vehicles by helping to motivate consumer purchase decisions. The program was originally designed to be "first-come, first-served" and only expected to be funded through 2015. Consequently, the program had no means-testing requirement at its inception, leading to a significant portion of incentives concentrated among high-income individuals.[2]

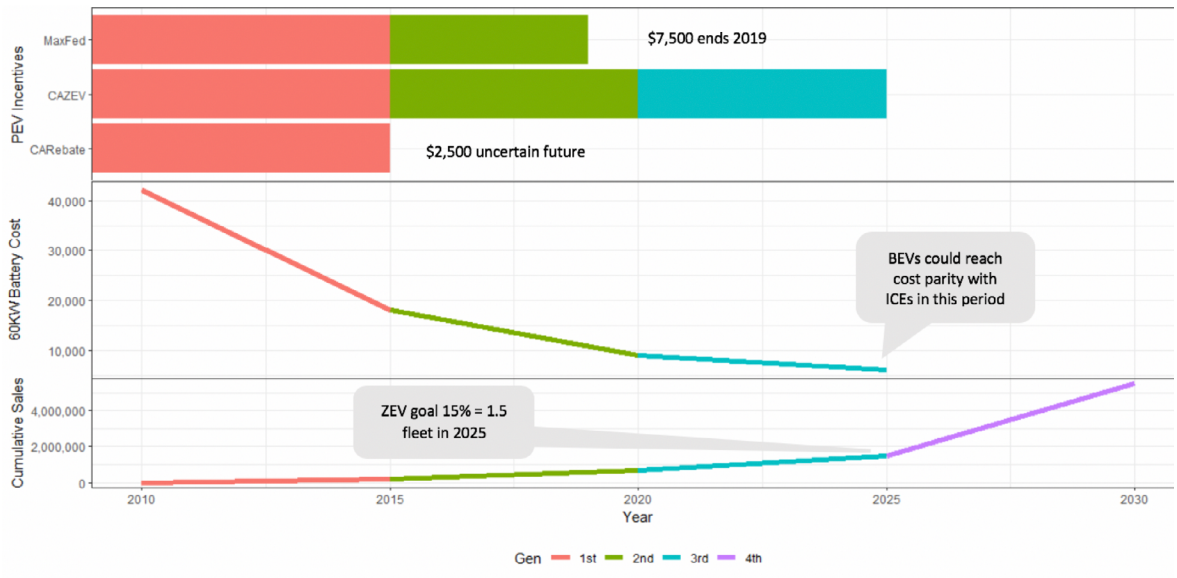
Senate Bill (SB) 1275, passed in 2014, was designed to address these issues. SB 1275 required CARB to develop a plan for realizing California's then-goal of achieving 1 million ZEVs on the road by 2023 without excluding low-income individuals. This bill required CARB "to adopt, no later than June 30, 2015, specified revisions to the criteria and other requirements for the Clean Vehicle Rebate Project; and to establish programs that further increase access to and direct benefits for disadvantaged, low-income, and moderate-income communities and consumers from electric transportation."[3] In March 2016, acting on CARB's recommendations, the state set an increased rebate of $1,500 for CVRP participants with incomes below 300% of the federal poverty level. In November 2016, SB 859 added an additional $500 rebate, bringing the total rebate to $2,000 for participants with incomes below 300% of the federal poverty level.[4]

3 Designing incentive programs

As seen in Figure 1, incentives are critical for spurring increased adoption in the first three generations of plug-in electric vehicles (PEVs).[5] Well-designed incentives should be efficient and equitable. Increasing ZEV incentive efficiency requires increasing the percentage of recipients who are induced to purchase a ZEV because of the incentive while decreasing the percentage of recipients who would have purchased a ZEV anyways. Increasing ZEV incentive equity means ensuring that incentives are evenly distributed across a range of demographics, especially income. These two objectives often go hand-in-hand, as low- and moderate-income individuals are the most likely to be influenced by incentives that reduce the financial impact of buying a ZEV. Failing to reach low- and moderate-income individuals will likely result in California missing its 5 million ZEVs by 2030 goal.

Multiple options exist for tackling both of these significant issues. Some have already been implemented in other

[2] Means testing is any requirement for a program that uses an individual's financial status to determine eligibility (normally income subset by tax filing status).
[3] It should be noted that while CVRP was an integral part of the state's efforts to increase ZEV adoption, the program was not the sole focus of SB 1275. For example, the mandate helped lead to the creation of EFMP Plus-Up, BlueLA, and Our Community Car Share.
[4] This income requirement changes depending on household size, increasing with each additional member.
[5] PEVs are a subset of ZEVs that excludes fuel-cell vehicles.



	1st Gen Innovators	2nd Gen Innovators & Followers	3rd Gen Innovators & Followers Next Purchase
PHEV Miles Traveled	10 – 40	15 – 50	50+
BEV Miles Traveled	80 – 250	150 – 300	200+
# of Models	20 – 30	30 – 100	200+
Designs	Compact, Subcompacts	Crossover, Midsize Sedans	Full-sized Vehicles

Figure 1. Charting the California plug-in electric vehicle (PEV) market from 2010–2030: past, present, and future.[6] *This figure highlights the importance of maintaining rebates (top panel) until battery-electric vehicles (BEVs) and ZEVs reach cost parity with internal combustion engine vehicles (ICEVs, middle panel). Moreover, these rebates will be necessary to spur enough adoption to reach California's ZEV goals (bottom panel). The figure also highlights the different stages of ZEV adoption (tables). Different groups of individuals are assumed to adopt ZEVs at different times. Innovators lead, then followers, then the second purchase of a ZEV by innovators and followers. Mass adoption occurs in the fourth generation.*

states, such as manufacturer's suggested retail price (MSRP) caps on EV rebates in New York, Massachusetts, and Connecticut.[7] Two different approaches were implemented in California in 2016: (1) income caps and (2) increased incentives for low- and moderate-income individuals. Income caps are designed to prevent subsidizing ZEV purchases for high-income individuals, since these individuals have the means to purchase a ZEV without assistance and will hence ascribe less value to financial purchase incentives. By preventing resources from being "wasted" on the wealthy, income caps increase incentive availability for low- and moderate-income individuals. This increases incentive efficiency and equity alike.

Another critical determinant of incentive efficiency and equity is outreach. For incentives to reach target populations, individuals in those populations must be aware of both the qualifying product and the existence of the incentive. Hence outreach around ZEVs in general as well as ZEV purchase incentives is an essential aspect of efforts to increase ZEV deployment.

This whitepaper focuses on literature and analysis relevant to providing increased CVRP rebates to low- and moderate-income ZEV buyers. For more information on the related policy of income caps, see a separate whitepaper in this series, "Impact of the Clean Vehicle Rebate Project's Income Cap on California's ZEV Market."

[6] Figure adapted from Turrentine et al. (2018). Note that CAZEV is comprised of all CA ZEV programs, including CVRP.

[7] MSRP caps essentially prevent expensive ZEVs like the Tesla Model X from qualifying for rebates, such that cheaper vehicles like the Chevy Bolt are the only subsidized ZEVs. These caps are designed to encourage manufacturers to produce vehicles that are more accessible to low- and moderate-income individuals. MSRP caps do not preclude high-income individuals from purchasing (and realizing subsidies on) eligible vehicles.

4 Key findings

These are the top findings based on our review of relevant literature.

- Low- and moderate-income consumers are more responsive to price than high-income consumers, meaning that low- and moderate-income consumers exhibit greater elasticity of demand for ZEVs—i.e., that demand decreases more given a set price increase (Muehlegger and Rapson 2018).
- Lower-income individuals and individuals who purchase vehicles with a lower MSRP generally state that rebates are more important to their purchase decisions (Williams 2018).
- Steep progressive rebates based on income may induce larger increases in demand than the status quo—a single increase for low-income and an income cap—in California (DeShazo et al. 2017).
- After CVRP rebates were increased for low- and moderate-income individuals and an income cap was introduced, the share of rebate recipients with household incomes below $50,000 annually increased from ~5% (in March 2016) to ~10% (in June 2017). The share of rebate recipients with annual household incomes between $50,000 and $150,000 increased as well (from ~21% to ~24%) over the same time period (Williams 2018).[8]

The literature generally suggests that without means-testing, ZEV purchase incentives tend to be concentrated among high-income individuals. Furthermore, these individuals are the least likely to consider a subsidy important in deciding whether or not to purchase a ZEV. While there is not much literature on the benefits of an increased rebate for lower-income individuals, Skerlos & Winebrake (2010) provide a roadmap for how rebates that vary based on income could help maximize ZEV adoption. DeShazo et al. (2017) similarly conclude that the most efficient policy for incentivizing increased EV adoption is a steeply progressive rebate based on income. These limited studies indicate that increasing rebates for low-income individuals has a positive effect.

Further research also needs to be done to assess the impact of increased rebates for low-income individuals with regard to the CVRP specifically. These impacts may become clearer with time; after all, it has only been three years since increased rebates were implemented for the CVRP. Early data is promising. Since the increased rebates were implemented, the percentage of CVRP recipients earning less than $50,000 annually increased from ~5% to ~10% (Figure 2).

5 Policy implications

Incentives that target specific purchaser types can be useful in achieving policy objectives

Multiple researchers (e.g., DeShazo 2010; Lee, Hardman, & Tal 2019; Pierce et al. 2019;, Skerlos and Winebrake 2010) have argued that targeting incentives towards specific purchasers can be useful in achieving policy objectives. The value that incentive targeting provides often justifies the added layer of policy complexity that targeting adds. Increasing ZEV purchase rebates for low-income individuals is a relatively straightforward example of incentive targeting.

Targeting ZEV purchase incentives to lower-income individuals can improve the efficiency of ZEV incentive programs

The objective of many incentive programs is to deliver social benefits by subsidizing technologies that deliver positive externalities. The CVRP subsidizes EVs in recognition of the social benefits they provide, such as reduced emissions and reduced demand for fossil fuels that can be costly to import and environmentally harmful to extract. Targeting ZEV purchase incentives to those (i.e., lower-income individuals) who are most likely to be influenced

[8] This could be attributed to both the income cap and the increased rebates, but the total volume of rebates was increasing at the same time, so the percentage change cannot be completely attributed to the exclusion of high income. Further research should try to disentangle these effects.

by such incentives can improve the efficiency of ZEV incentive programs, thereby increasing the social benefits realized for a set program cost. Lower-income groups are also less likely to own reliable vehicles, which leads to employment and community challenges. Targeting ZEV purchase incentives to lower-income individuals can help address this issue as well.

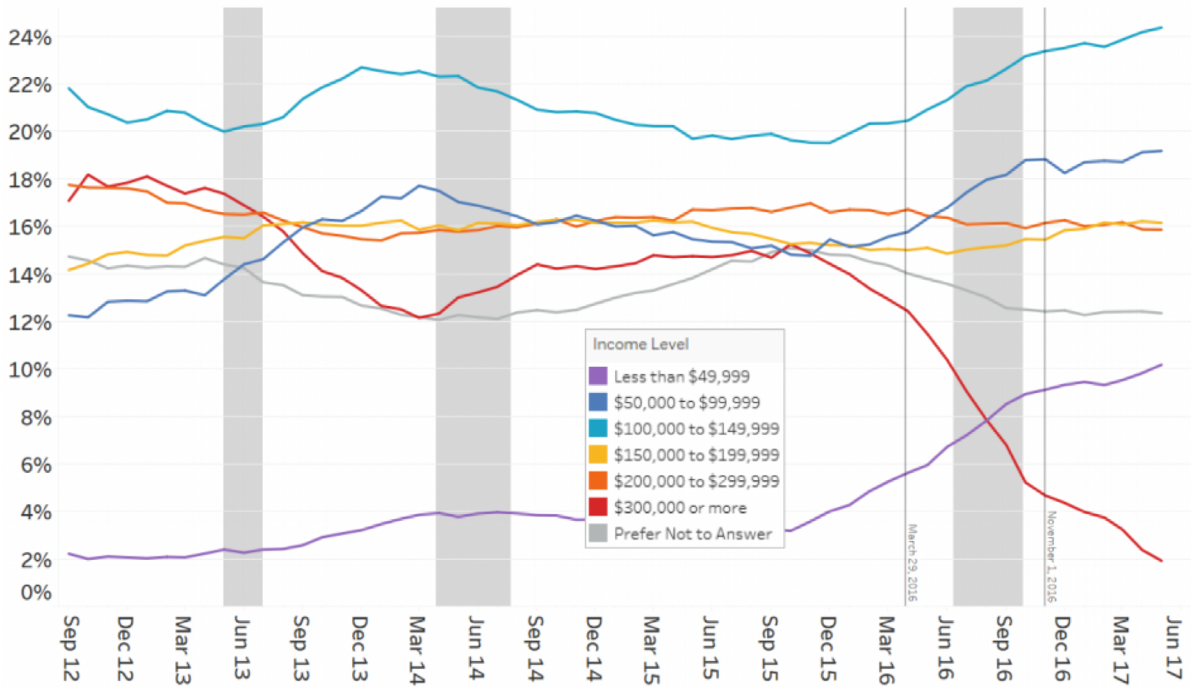


Figure 2. CVRP rebates by household income over time.[9] *This figure shows the percentage trend of CVRP rebates dispersed by household income bracket. The income cap and increased rebates implementation/adjustment are indicated by the two gray lines (March and November 2016). There is a marked decrease after March 2016 in rebates received by households earning $300,000 or more annually, and a significant increase among those earning less than $50,000 annually. This comparison gives us an indication of the effectiveness of means-testing policies on increasing equitability of rebates.*

Implementing targeted incentives for more populations could accelerate ZEV adoption

In the coming years, EVs will be purchased by a widening variety of customers. Targeting incentives to different population groups could ensure that appropriate incentives are delivered to those most likely to benefit from and/or be influenced by them. For instance, financial incentives could be targeted across more income brackets in order to better match rebate amounts with ability to pay (DeShazo 2010; DeShazo et al. 2017; Lee, Hardman, & Tal 2019; Pierce et al. 2019; Skerlos & Winebrake 2010). Other incentives, such as priority access to high-occupancy vehicle (HOV) lanes for ZEV purchasers, could be targeted to those for whom cost is less of an object (Jenn et al. 2019). Further targeting is likely to further increase efficiency and equity of ZEV incentive programs.

Availability of rebates will likely be an important determinant of future ZEV adoption rates

While rebate policy should be designed with its long-term existence in mind, incentives will be needed to sustain ZEV adoption for the foreseeable future. In seeming contradiction to the “common paradigm” shown in Figure 3, research shows that the importance of rebates in California has actually increased over time (Williams & Anderson 2018). This research is also supported by two major surveys that stress the growing importance of incentives for ZEV adoption (Jenn et al. 2019; Lee, Hardman, & Tal 2019). As the market has expanded for ZEVs, the importance of the rebate has consistently increased, indicating that if the government wants to spur more growth, the rebate will likely need to remain in place. This is likely due to an influx of more price-sensitive customers entering the

[9] Figure taken from Williams (2018).

ZEV market—due to increased outreach and implementation of increased rebates for low- and moderate-income individuals—and points to the importance of a long-term perspective.

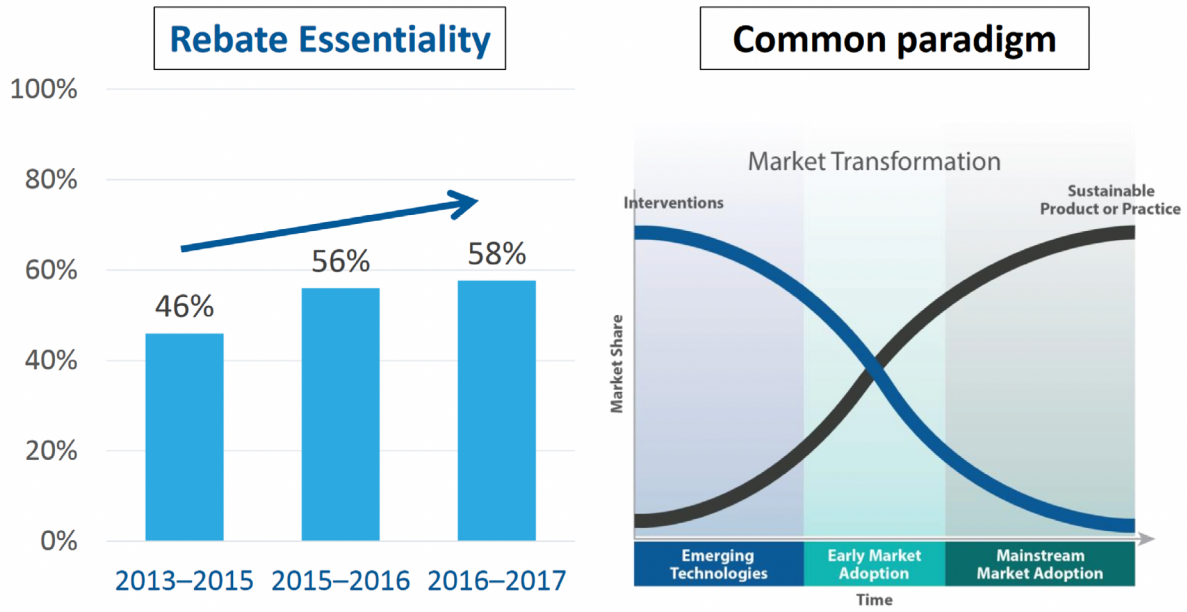


Figure 3. CVRP rebate essentiality over time, in contrast to the common paradigm.[10] *Rebate essentiality is determined by asking rebate recipients if they would have purchased a ZEV without a rebate, which demonstrates how "essential" the rebate was to the purchase.*

6 Highlighted works

This section summarizes some top findings and key methodological choices for the reviewed papers.

General (non-California-focused) studies

General incentive studies (overall effectiveness & effectiveness among low-income)

Beresteanu & Li (2011)
Study type: Observed data analysis
Geography: United States

The authors study the effect of gasoline prices and federal tax incentives on hybrid electric vehicle (HEV) sales. Using both household-level data and aggregate market-level sales data, the authors estimate a market equilibrium model. The authors attempt to estimate the net effect of tax deductions and credits by simulating the benefits to three income groups: those earning less than $50,000 annually, those earning between $50,000 and $100,000, and those earning more than $100,000. The authors found that the lowest-income group was about twice as sensitive to prices as the middle group, while the highest-income group was one-third as sensitive to prices as the middle group.

Diamond (2009)
Study type: Observed data analysis
Geography: United States

The author attempts to determine the factors driving HEV adoption in the United States using simple regressions on a panel dataset of market shares of different vehicle types in different states. The author finds no significant

[10] Figure taken from Williams & Anderson (2018).

relationship between financial incentives and HEV adoption since incentive payments tend to be concentrated among high-income consumers who have sufficient tax liability to benefit, effectively subsidizing the wealthy without significantly affecting their purchase decisions. Note that consumer eligibility to claim and benefit from CVRP cash rebates does not depend on tax liability.

Gallagher & Muehlegger (2011)
Study type: Observed data analysis
Geography: United States

The authors report that HEV sales increase more in response to sales tax exemptions than to income tax credits/exceptions. This paper is loosely related to distributional concerns as it implies that consumers at all income levels are more responsive to subsidies with immediate effect.

California-focused studies

General incentive studies (overall effectiveness & effectiveness among low-income)

Muehlegger & Rapson (2018)
Study type: Observed data analysis
Geography: California

The authors attempt to determine the effectiveness of incentives for EVs in the mass-market, specifically those aimed at low- and moderate-income consumers in California. Through transaction-level data, the authors determine that low- and moderate-income consumers are very sensitive to rebates and that at current subsidy levels the entirety of the rebate is needed to induce purchase. Overall, this paper indicates that low- and moderate-income users significantly benefit from EV rebates and that rebates induce purchases without significant free-riding within those income groups.

Jenn et al. (2019)
Study type: Survey
Geography: California

Using a comprehensive survey of over 14,000 ZEV purchasers in California, the authors analyze individuals' stated reasons for ZEV adoption. The most important factors for PEV adoption are the federal tax credit, the CVRP, and High Occupancy Vehicle (HOV) lane access. The authors further find that the importance of incentives and incentive effect on purchase intentions are changing over time as ZEV technology and trends move towards the mass market and away from early adopters. They conclude that if rebates are removed, respondents would be more likely to change their decision and not purchase a ZEV at all.

Lee, Hardman, & Tal (2019)
Study type: Survey
Geography: California

The authors use a multi-year survey (2012–17) of the socio-demographic characteristics of 11,037 PEV adopters in California to analyze the different characteristics that drive early PEV adopters. This analysis identifies four groups of PEV buyers: high-income families (accounting for 49% of adopters), mid- to high-income older families (26%), mid- to high-income young families (20%), and mid-income renters (5%). The authors find that while high-income families are currently the largest group of PEV adopters, the relative size of this group may be decreasing. The authors stress the importance of meeting needs of the other groups in order to continue PEV market growth.

Explicitly low-income incentive studies

DeShazo et al. (2017)
Study type: Observed data analysis
Geography: California

The authors assess the performance of rebate designs for plug-in electric vehicles (PEVs) based on cost-effectiveness and equity. They perform a state-wide representative survey of prospective car buyers in California, which informs a structural model of vehicle choice. The empirical model estimates price elasticities of demand and willingness to pay for different vehicles, which in turn permits a simulation of alternative rebate designs. The rebate designs are compared over three main criteria: (1) additional PEVs purchased; (2) total program cost; and (3) the distribution of rebate funding across consumer income classes. Finally, the paper finds that progressive rebates (a specific, steep set) are likely to be more effective across all observed measures than the status quo.

Pierce et al. (Forthcoming)
Study type: Survey
Geography: California

Using a statewide survey of 1,604 low- and moderate-income households, the authors conduct choice experiments to determine if PEV purchase incentives are cost-effective. They find that rebates of $2,500, $5,000, or $9,500 increase PEV purchases by around 20%, 40%, and 60–80%, respectively. Incentives had a significantly larger influence on purchase decisions than did guaranteed financing options. However, offering both together another did not significantly increase purchase intentions relative to offering only the rebate. This research indicates that incentives may be a cost-effective way to increase PEV adoption among low- and moderate-income households.

Williams (2018)
Study type: Initial data analysis
Geography: California

The author finds that since the introduction of CVRP income caps and increased rebates, the share of rebates received by households with annual incomes of more than $300,000 dropped from ~16% to ~2% (in June 2017). The share of rebate recipients with annual household incomes below $50,000 increased from ~5% to ~10% over the same time period, and the share of rebate recipients with annual household incomes between $50,000 and $150,000 increased as well (from ~21% to ~24%). The author also finds that rebate recipients are increasingly demographically similar to new car buyers overall, and that rebate importance for purchase has increased over time.

Williams & Anderson (2018)
Study type: Observed data analysis
Geography: California

The authors use logistic regression to examine the relationship between rebate influence and consumer factors (demographic, household, and transaction characteristics; motivations; and experience). They find that if household income has become a poorer indicator of proclivity to purchase a ZEV, this is likely due to the means-testing implemented for CVRP in 2016. This also finds that traditionally higher-income complements—such as housing type, solar panels, workplace charging availability, and size of household—were all insignificant predictors of proclivity to purchase a ZEV. This may suggest that ZEVs are suitable for a diverse set of consumers.

Arguments for means-testing

DeShazo (2010)
Study type: Literature review
Geography: United States and California

The author provides a first-principles review of the economics behind and the characteristics of EV subsidies, as well as a history of EV subsidies in California. The author notes that EV subsidies are effective but inefficient, and recommends: (1) applying subsidies at point of sale; (2) increasing subsidies for BEVs relative to PHEVs; (3) linking vehicle purchase and retirement incentives; and (4) means-testing subsidies.

Skerlos & Winebrake (2010)
Study type: Observed data analysis
Geography: United States

The authors discuss the regional variability of PHEV social benefits and conclude that a uniform national policy for subsidizing PHEVs is at best sub-optimal, meaning that greater PHEV benefits could be achieved for the same government investment if subsidies were targeted to where the social benefits are largest. They argue that the federal PHEV tax credit would have higher social benefits if it were varied across income and location.

7 Ongoing research

The majority of ongoing research focuses on the characteristics of ZEV buyers and how those characteristics are changing over time. Ongoing research also considers how these characteristics affect purchase intentions and preferences regarding ZEVs. Preliminary results support—albeit based on much more data, especially for California—previous findings regarding the characteristics of ZEV buyers and the need for increased incentives and attention to low- and middle-income individuals.

8 Research gaps

Gaps in the research that could be filled by more targeted research efforts resulting from collaboration between academic researchers and regulatory agencies include:

- Econometric assessments of the effects of the CVRP's increased rebates, i.e., that go beyond simple before-and-after comparisons.
- Analysis of decreasing average ZEV MSRP on rebate effect.
- Analysis of the extent to which varying rebate amounts based on income would alter rebate effectiveness.

The research in its current state only allows for basic before-and-after comparisons of rebate recipient demographics, tangential inferences from other programs, and research on the drivers of ZEV purchases among high-income individuals. To fully understand the impact of increased rebates for low-income individuals in general, and for CVRP specifically, more methodologically rigorous analyses need to be conducted.

The short time frame from when means-testing was implemented for CVRP (March/November 2016) does not lend itself to comprehensive analysis of the program's long-term impacts. However, the short-run impacts of these policies can be a bellwether for policymakers on how effective the program may be in the long run, and thus analyses can and should be done. It is particularly important to determine how many new ZEV purchases were induced by the increased rebates for low-income individuals—i.e., how many of these purchases would not have occurred had the rebates not been increased.

Several of the research questions posed above could be examined through difference-in-differences studies focused on the time period before and after means testing for the CVRP was implemented. Carrying out such a

study would require an appropriate control/counterfactual. This would likely be difficult at the state level. It may be easier to conduct such studies on different areas of California that have larger or smaller low-income populations, but are similar on other characteristics. One shortcoming of this approach is that it would have limited ability to parse the relative effects of adding an income cap for ZEV rebates and of increasing rebates for low-income individuals, since these two methods of means testing were implemented for the CVRP simultaneously.

Another approach would be a regression discontinuity study design that looks at similar individuals who just barely fall on either side of the income rebate cutoff. Such a design has high data requirements and has so far proven challenging. Researchers should looking to other branches of economics for alternative study designs that may be valuable when it comes to informing future changes to the CVRP.

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