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Exploring the Impact of the Federal Tax Credit on the Decision to Lease or Purchase a PEV in California

May 2023

A Research Report from the National Center for Sustainable Transportation

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Exploring the Impact of the Federal Tax Credit on the Decision to Lease or Purchase a PEV in California

A National Center for Sustainable Transportation Research Report

May 2023

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Exploring the Impact of the Federal Tax Credit on the Decision to Lease or Purchase a PEV in California

EXECUTIVE SUMMARY

Plug-in electric vehicles (PEVs) play an important role in reducing energy consumption and emissions from transportation. PEVs are key to meeting greenhouse gas and criteria pollutant emission, human health, eco-system and economic resilience, and renewable energy goals (Energy Agency, 2021). The federal government provides up to a \$7,500 tax credit rebate for financing a battery electric vehicle (BEV) and plug-in hybrid electric vehicles (PHEVs). Historically (2008-2022) this credit applied until a manufacturer reaches 200,000 PEV sales, at which point the incentive were phased out. Beginning January 2023, changes to incentives will mean all automakers can receive incentives until 2032 subject to some limitations on vehicle price, vehicle & battery production, and buyer income. This project explores the impact of pre-August 2022 federal tax credit on lessees' and purchasers' decision to adopt a PEV, though the results will be still relevant for the revised federal tax credit. As California transitions from vehicle sales dominated by conventional gasoline vehicles, to the goal of 100% ZEV sales by 2035, it is critical to better understand the impact financial incentives are having on consumers decision to adopt a PEV. This is especially pertinent as the federal tax phase out began for the Tesla Model 3 and Chevrolet Bolt in 2018 and 2019 respectively. More recently changes to the federal tax credit mean many PEV models, mostly those made outside of the USA no longer receive any incentive, and many made in the USA may only receive half of the potential full value.

Leasing is alternative acquisition method to purchasing which allows consumers to limit their vehicle ownership period to most commonly a 36-month long contract. The federal tax credit is also administered differently depending on finance method. Since the dealership owns any leased vehicles, they are the recipients of the tax credit, which they apply to lessees immediately through lower down and monthly payments. Purchasers alternatively receive the tax credit once they file for taxes, and may not receive the full amount if their tax liabilities are less than the credit amount.

PEV leasing may be important to the PEV market for several reasons: it could help lower the cost of PEV acquisition since buyers receive the credit at the point of payment, allow consumers to trial the technology with a shorter ownership period, and increase the turnover of PEVs on the road, creating a supply of used PEVs faster than purchasing could. Leasing has steadily grown in new sales share in the vehicle market beginning in the 1990's. However, the PEV market has witnessed a higher lease rate than for conventional gas vehicles. According to the 2019 California Vehicle Survey, 22% of conventional gas vehicles were leased compared with 60% of BEVs not including Tesla. While previous research has found that consumers are more likely to lease a PEV with attractive terms relative to purchasing, the phase of the tax credit could have a major impact on the attractiveness of leasing a PEV (Hoogland et al., 2022). Existing research has either focused exclusively on purchasers, or has combined purchasers and

lessees into one category. Nonetheless, these findings reveal that the federal tax credit is the most important incentive for consumers' purchase decision, and may be attributed to over 30% of PEV sales in the U.S. (2,3).

Using a sample of approximately 7,000 California PEV drivers recruited from California Clean Vehicle Rebate Program applicants, two logistic regression models are specified to analyze responses by PEV lessees and purchasers to the question of what they would do in the absence of the federal tax credit. Possible responses include: Purchase/lease the same PEV, switch to a different PEV, switch to a conventional or hybrid (non-plug in) vehicle, or do not acquire a vehicle at all. Several key insights are found. There is a smaller proportion of PEV lessees who report they would still lease their PEV if the federal credit wasn't available, compared to those that purchased a PEV. This may mean the federal tax credit is more influential in buyers decision to lease a PEV compared to buyers decisions to purchase a PEV. Higher discounts from the tax credit increase the probability of lessees choosing not to lease a PEV at all. For purchasers, in addition to not purchasing any vehicle at all, the probability of purchasing a conventional vehicle, or another PEV also increase. These findings could have implications for California's ability to reach its ZEV milestones. Our findings indicate that some PEV adopters would likely not adopt a PEV without the tax credit, potentially more so for leased compared to purchased vehicles. Fewer leased PEVs could also translate to lower rates of non-ZEV retirements, since the federal tax credit may encourage consumers to lease a PEV when they otherwise were not considering a new vehicle. There are also unique results for lessees related to the impact of home ownership; renters are more likely than homeowners to lease a conventional vehicle than a PEV in the absence of the tax credit. This finding contributes to the literature which finds home owners to be more likely to adopt a PEV than renters, emphasizing the importance of access to at-home charging for PEV adoption. These results clarify how PEV lease decisions are unique compared to purchase decisions, and the factors which are associated with consumers' PEV adoption behavior in the absence of the federal tax credit.

Introduction

The state of California has been a leading state in growing the market share of plug-in electric vehicles (PEVs). Several policy tools have been utilized in the state and the US to help support the PEV market. The state offers financial incentives, including rebates through the California Clean Vehicle Rebate Program (CVRP), and has a mandate which requires automakers to sell a portion of their vehicles as PEVs or fuel cell vehicles. In addition to these state policies, the federal government provides up to a \$7,500 tax credit for financing a battery electric vehicle (BEV) or plug-in hybrid electric vehicles (PHEVs). This credit originally phased out at the beginning of the second calendar quarter after a vehicle manufacturer has sold 200,000 eligible PEVs. The incentive halves to \$3,750 for two quarters, halves again to \$1,875 for two quarters, and then becomes \$0. Both Tesla and Chevrolet had reached this point and as of the beginning of 2020 buyers of neither make were eligible to receive credits. The federal tax credit can be claimed by purchasers when they file taxes for the year in which they purchase the vehicle. The credit can be applied to leased vehicles through the lessor claiming the incentive and using it to subsidize lease payments. Recent changes to federal EV tax credit through the 2022 Inflation Reduction Act removed the 200,000 vehicle cap which means Tesla and Chevrolet vehicle buyers will be eligible for up to \$7,500 beginning in January 2023. Incentives will be available until 2032, but new stipulations in the federal tax credit on where batteries are produced and vehicle purchase price mean more than half of PEVs may receive no incentive, and the ones that do will receive only half of the full amount (Title I-Committee on Finance-Deficit Reduction, 2022). Further changes on buyers income mean higher earners will also not receive an incentive. These changes may have implications for PEV market growth, particularly California's goal of 100% ZEV sales by 2035.

Leasing is an alternative acquisition method to purchasing which allows consumers to limit their vehicle ownership period to most commonly a 36-month long contract. The federal tax credit is differently for lessees and purchasers. Lessees in theory receive the full benefits of the federal tax credit sooner than purchasers, since the credit is administered to the dealership. It is assumed that the tax credit is then reflected in lower down and monthly lease payments. Anecdotal evidence from Green Car Reports in 2021 confirmed that lease payment increased drastically for certain PEVs such as the Toyota Rav4 Prime and Prius Prime soon after the federal tax credit expired for the respective models (5). Purchasers on the other hand don't receive the credit until they file taxes for that year, and may not apply for the full amount if their tax liability is less than the amount of the tax credit. This delay in receiving the incentive and uncertainty in the value received could limit how effective the incentive is for purchases, while an immediate discount on leased PEVs could mean the incentive is more impactful.

Leasing is an important segment for the PEV market for several reasons: it may encourage more consumers to finance PEVs at a lower acquisition cost and allow buyers to try a PEV over a set time which could lower the perceived uncertainties of PEV adoption as the technology matures. In theory, this could make PEVs more accessible to a wider group of consumers, and create a supply of used PEVs faster than purchasing. Vehicle leasing experienced a period of rapid growth from the 1980's to 1990's, accounting for a quarter of new vehicle sales by the late

1990's. This share has slowly increased; according to Edmunds (2017), leasing accounted for 31% of all new vehicle sales in 2016. This trend continued to 2019 when 30% of vehicles were lease, more recently leasing has declined to 19% of new vehicle sales (7). This decline in leasing may be short term and could be connected to higher vehicle prices, tighter vehicle supply, higher interest rates, and fewer lease offers.

Focusing on the light-duty vehicle fleet in California, according to the California Vehicle Survey (8), 32% of the “2015 and later” model year vehicles were leased new.¹ Figure 1 shows that in the unweighted sample of vehicles surveyed in the 2019 CVS, approximately 33% of the PEVs of model year “2015 and later” were leased new compared to 22% of conventional gas vehicles. The share of leased BEVs rises to 60% when we consider the subsample of surveyed PEVs without Tesla. Tesla did not initially offer vehicles for lease, and they tend to not offer discounted lease rates.

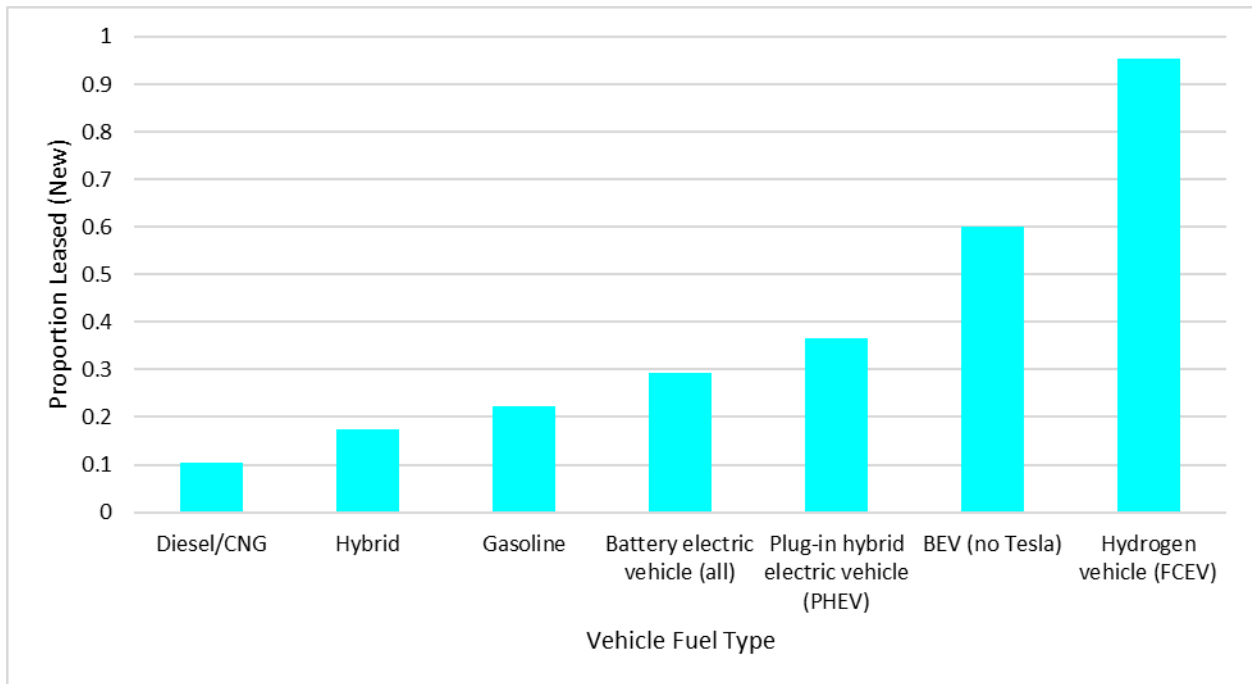


Figure 1. Proportion of leased passenger vehicles among different fuel types (new; model year 2015 and later); data from California Vehicle Survey (8).

Existing research on the impact of financial incentives does not directly explore PEV leasing—either by not differentiating purchasers from lessees, or by focusing only on purchasers. This presents a gap in the literature on understanding of how the absence of the tax credit may uniquely impact the attractiveness of leasing a PEV. While there is limited research on the PEV leasing, Hoogland et al. (9) found that PEV owners are more likely to lease PEVs with discounted

¹ In the 2019 California Vehicle Survey, we focus on vehicles that were purchased or leased new (reported). Moreover, to investigate the purchase/lease share in the sample we consider model years 2015 and later assuming that vehicles are generally leased for 3-5 years.

lease rates relative to purchasing. However, as the federal tax credit expired for various PEV makes/models and may not be available to many PEVs due to changes to the federal tax credit, it will be critical to understand how the absence of this incentive could impact future PEV leasing. Furthermore, this research provides insights into PEV market characteristics segmented by finance method. This research explores how socio-demographics, household and vehicle characteristics impact consumers' adoption decision in the absence of the tax credit. Two models are developed to explore the factors which are associated with lessees' and purchasers' PEV adoption decision respectively.

Literature Review

There are several relevant areas of literature to this study: those which explore the factors associated with PEV adoption, the impact of financial incentives on PEV adoption, and particularly the impact of the federal tax credit, as well as those which explore contract choice (purchase or lease) in both the internal combustion engine vehicle (ICEV) and PEV market.

Revealed preference, as well as stated preference data in the U.S., Canada, and Switzerland have demonstrated that PEV adopters are more likely to be in a higher income class, well-educated, male, homeowners, residing in a single-family home, and are also more likely to have previously owned a hybrid vehicle, and be technology enthusiasts (10–16). Lee et al. (16) characterized PEV adopters in California from 2010 to 2017 by identifying four unique clusters of adopter groups: high income families, mid/high income young families, mid/high income old families, and middle-income renters. Authors conclude that more middle-income renters need to adopt PEVs at a higher rate for PEV market growth to continue.

Financial incentives have also been found in both stated and revealed preference studies to be effective in increasing PEV adoption. (12,17,18). Gong et al. (19) explored the impact of government incentives on the market penetration of PEVs in Australia. Authors found that incentives which decrease the upfront costs are the most preferred financial incentive. In a literature review of PEV financial incentives. Hardman et al. (20) additionally found that for adopters of high-end PEVs, financial incentives are not important in consumers' adoption decision, recommending that financial incentives not be applied to high-end PEVs, but on lower MSRP PEVs in order to attract more consumers. Jenn et al. 2018 examined the effectiveness of financial and non-financial incentives on PEV adoption in the U.S. Authors conclude that for every \$1,000 offered as a rebate or tax credit, average PEV sales increase by 2.6%. Tal and Nicholas (2) utilized a stated preference survey of PEV owners to examine the impact of the federal tax credit, and found that more than 30% of PEV sales could be attributed to the \$7,500 incentive. Jenn et al (3) found that incentives are growing in importance over time in regard to determining consumers' stated preference decision to adopt a PEV or not, but that for particular groups of consumers, such as older and wealthier consumers, the absence of the federal tax credit is less likely to change their purchase decision.

There is limited literature on contract choice in the PEV market. Liao et al. (21) explored the potential of leasing in promoting the transition from ICEVs to PEVs. Results from latent transition analysis showed that leasing could facilitate PEV adoption for the subset of

consumers with pro-leasing and pro-convenience preferences. In another stated choice experiment examining consumer preference for various PEV business models, Liao et al. (22) found that consumers perceived leasing as attractive for BEVs, and purchasing attractive for PHEVs. The authors also find that PEV market share increases when financial incentives are offered to both PEV lease and purchase contracts, rather than just purchases. Lastly, Hoogland et al. (9) explored the factors associated with the decision to lease, rather than purchase a PEV in California, and found that PEV leasing was associated with renting, rather than owning their home, as well as with living in a non-single-family home.

Even for the ICEV market, there is limited research on consumer contract choice, and its influence on vehicle choice, as this Mannering et al. (23) used a random sample of 654 households to jointly model the vehicle finance method and vehicle choice. The authors found leasing to be associated with high income consumers, authors hypothesize that leasing could be a mechanism for this group of households to upgrade their vehicle every few years or to lower transaction costs associated with vehicle disposal. Authors also find consumers are more likely to lease a vehicle if they had previously leased one, referred to as exhibiting lease loyalty. Dasgupta et al. (2007) implemented a structural model using transaction data for new vehicle sales from the entry-luxury segment of the U.S. auto market. Authors conclude that leasing allows consumers to drive two new vehicles over the average vehicle ownership period, while also having lower disposal costs relative to purchasing. Trocchia and Beatty (25) found through exploratory interviews, that desire for variety and desire for easier maintenance motivated consumers to lease a vehicle.

Data Description

We use results from a cohort survey of electric vehicle owners in California conducted in 2019. The respondents of the survey are sampled from the pool of California Clean Vehicle Rebate Project (CVRP) recipients, a rebate program for purchasers and lessees of electric vehicles within California. The CVRP is administered by the Center for Sustainable Energy & California Air Resources Board, who have an agreement with the University to provide contacts (e-mail) for solicitation for the purposes of disseminating and gathering respondents for the survey. Altogether, phase 5 include 7,078 respondents, all of whom have applied for the CVRP rebate following the purchase or lease of a PEV.

Data Screening

The data for our analysis includes PEVs which were either purchased or leased new from 2018 to 2019². The data screening process varies depending on finance method. Please refer to the appendix for the distribution of makes and models in the pre-screened and screened lessee and purchaser sample.

² While phase 5 of the survey was administered in 2019, it includes a small number of observations for finance years in 2017 and earlier. These are excluded from analysis.

For purchasers:

1. Stated-importance of the federal tax credit and other financial and non-financial incentives from “not important” to “very important” (-3 to 3):

1a. Plug-in cars are eligible for different local, state, and federal incentives. How important were those incentives in your decision to buy the PEV?

1b. [How much is this incentive for your household?]

2. Based on the ratings of incentives, a rank order is created:

Based on your answer for the incentives above, we created this table below ranking your incentives. Does this order reflect the importance of those incentives on your decision of buying your PEV? If not, please reorder the list from the most important to the least important.

3. The choice alternative question is asked only to those who ranked the federal tax credit as their #1 ranked financial incentive, 54% of the purchase sample (2,764 of 5,080 purchasers)

If the [tax credit] were not available when buying my PEV (or any other plug-in vehicle) I would have chosen:

- *A conventional or hybrid vehicle (non-plug in vehicle)*
- *Another plug-in vehicle*
- *Not to buy a vehicle at all*
- *The [same] PEV*
- *Other*

For lessees:

1. All lessees, with the exception of Chevrolet and Tesla lessees³ are asked the choice alternative question. Due to uncertainty about lessees’ awareness of how the credit is administered , they were not asked to first rank the federal tax credit. Thus, the choice alternative question provides education and uses the participants’ reported down and monthly payments to impute the lease cost without the credit discount:

The US federal tax incentive is applied to your lease price. Without the tax credit we estimate your down payment would have been [X] rather than [Y] and your monthly payments [W] rather than [Z] for [N] months. If that would have been the lease payment for my PEV, I would have chosen:

- *A conventional or hybrid vehicle (non-plug-in vehicle)*
- *Another plug-in vehicle*
- *Not to lease a vehicle at all*
- *The [same] PEV*

³ The phase-out of the federal tax credit began for the Tesla Model 3 and Chevrolet Bolt in 2018 and 2019 respectively. Due to the uncertainty regarding the discount amount received during this period of phase-out, Tesla and Chevrolet lessees were not asked the response variable question.

- Purchase or finance the PEV
- Other

Please refer to the Appendix for a comparison of participants’ reported credit amounts with the maximum eligible credit, based on battery size and model year. Figure 2 shows the distributions of incentive rankings generated from survey question #2, for lessees and purchasers respectively. These include both financial incentives from the federal government, state, local governments, or utilities, and the non-financial incentive of HOV lane access. Over half of purchasers ranked the federal tax credit as the most important incentive in their decision to purchase PEV, followed by the state incentive. The state incentive is the highest ranked financial incentive for the majority of lessees. Lessees also have higher proportion of respondents reporting the HOV lane as their highest ranked non-financial incentive compared with purchasers.

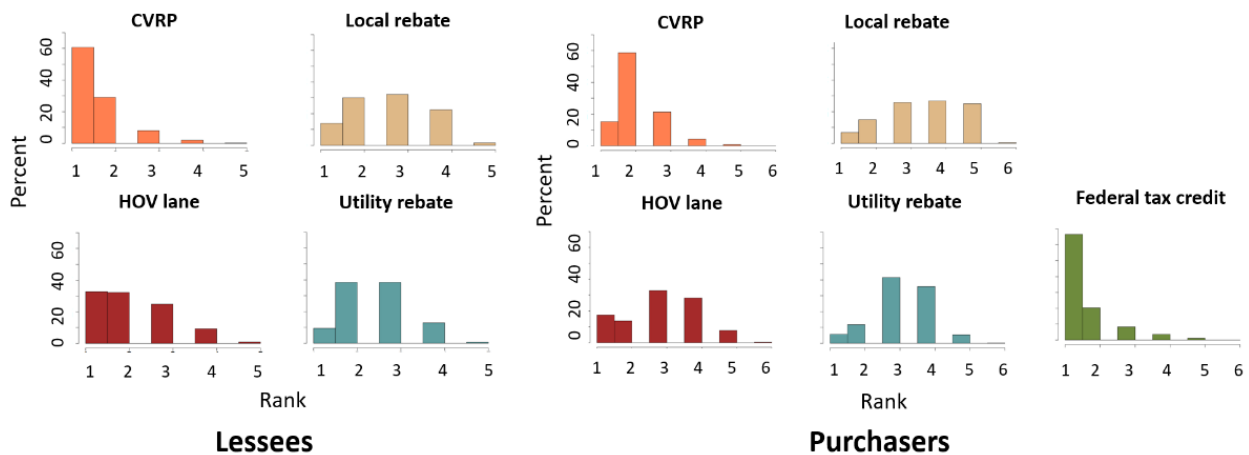


Figure 2. Distribution of incentives rankings for lessees and purchasers (“Based on your answer for the incentives above, we created this table below ranking your incentives...”)

Figure 3 provides a distribution of the choice alternatives generated from survey question #3, for lessees and purchasers respectively. Overall, given an absence of the tax credit, there is a larger proportion of purchasers choosing the same PEV relative to lessees choosing to lease the same PEV, and a smaller proportion of purchasers choosing a conventional vehicle, or another PEV relative to lessees. There are roughly the same proportion of lessees and purchasers choosing no vehicle at all.

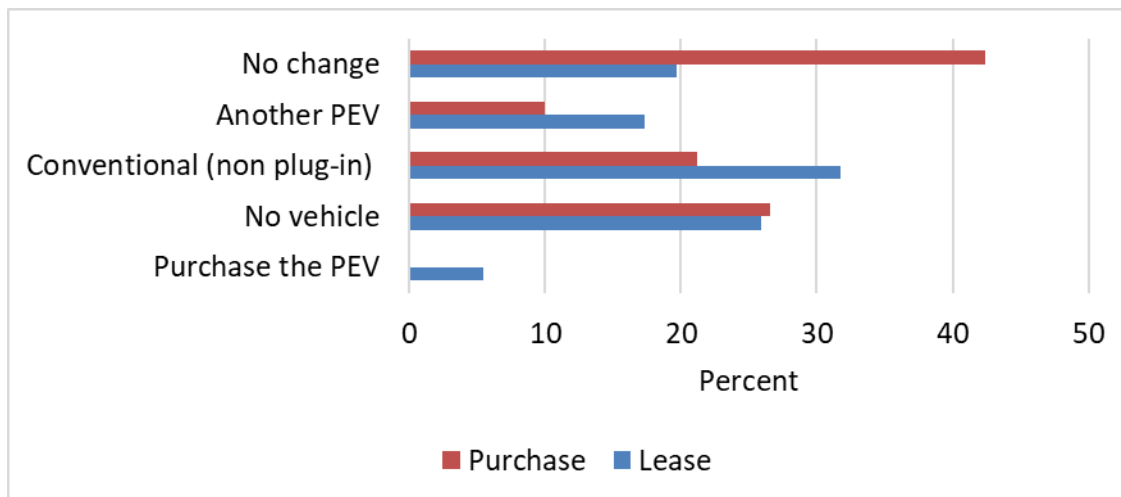


Figure 3. Distribution of responses for choice alternative separated by finance method

Methods

Model Specification

Two standard multinomial logistic (MNL) regression models are specified to separately model the impact of the federal tax credit on the decision to lease or purchase a PEV.

Figure 4 shows the alternatives in the choice set for the two models. Both models capture change in consumers' adoption behavior in the absence of the federal tax credit, with each choice alternative having a vector of parameters which are alternative specific. For purchasers, the reference category captures simply no change in purchase behavior (adopting the same PEV), relative to purchasing another PEV, no vehicle, or a conventional (non-plug-in) vehicle. Due to the low number of observations for lessees, the choice alternatives "no change", and "another PEV", are combined to form the reference category referred to as leasing a PEV, relative to leasing no vehicle at all, a conventional (non-plug-in) vehicle⁴. Lessees have the additional choice alternative of purchasing/financing the PEV, of which there is no equivalent choice for purchasers.

⁴ Results of likelihood ratio test showed that there was no statistical difference between the lease model with the combined reference category and the single reference category.

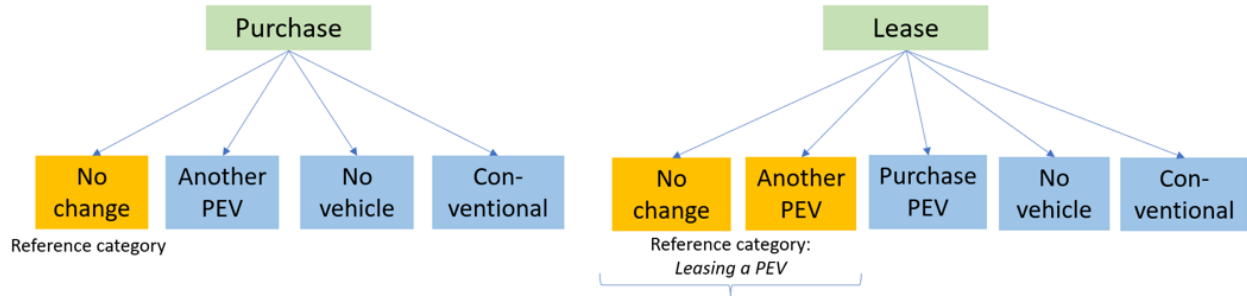


Figure 4. Choice alternatives for Purchase and Lease MNL models

Variable Selection

Table 2 provides an overview of the models' control variables, based on literature of PEV adoption and vehicle financing. In addition to estimating the main effect for PEV type, an interaction effect between electric range and PEV type is also defined in the models. Additional vehicle characteristics include the vehicle MSRP, the tax credit discount percent, year it was financed, and for lessees, the lease contract length. To calculate the discount percent, we use the discount amount reported by participants. We also control for socio-demographic factors such as male/female distinction, age, home ownership, and number of household vehicles per driver.

Table 1. Variables included in MNL models and description of variable values

Variable	Description and values
PEV Type	Dummy, (BEV = 1, PHEV = 0)
MSRP	Discrete, Proxy for vehicle price.
Discount percent	<i>For lessees:</i> the full applicable incentive discount is divided by what the lease cost would have been without the incentive <i>For purchasers:</i> The discount received from the tax credit is divided by what the price would have been without the credit.
Electric range	BEVs: 84 to 310 miles PHEVs: 17 to 84 miles
Finance Year	Dummy, (2019 = 1, 2018 = 0)
Male distinction	Dummy, (Male = 1, Female = 0)
Age	Midpoint of age category (16.5, 24.5, 34.5, etc.)
Home Ownership	Dummy, (Own = 1, Rent = 0)
Number of drivers per household vehicle	Discrete from 0.2 to 3.
Lease contract length	Discrete, from 24 to 60 months

Table 3 provides a comparison, when applicable to the sociodemographic profile of California from the 2019 5-year American Community Survey. As seen, the sample of respondents have a

much higher income than the average Californian; the difference is even greater for purchasers. Additionally, a significantly higher proportion of the sample live in a single-family home, which they own, and are male, compared with the state average. Most participants in the sample for both purchasers and lessees are between the age of 40 to 59. Though we provide descriptive statistics for income across purchasers and lessees, due to the large number of missing observations for income, it is not controlled for in either of the MNL models.

Table 4 provides a comparison of vehicle characteristics between lessees and purchasers in the sample. In regard to PEV type, approximately 60% of leased PEVs were BEVs, whereas approximately 80% of purchased PEVs were BEVs. Purchased BEVs also have higher electric range than leased BEVs, due to there not being any Tesla makes/models in the lease sample. There are also fewer PEVs leased in 2019 compared with purchasers, most likely due to the release of the Tesla Model 3. On average, the federal tax credit discount is much higher for lessees, due to the lower average lease costs compared with the purchase price for any given PEV. Additionally, the average MSRP of purchased PEVs is slightly higher than leased PEVs. Lastly, a majority of the lease contract lengths were 36 months long.

Table 2. Sample Descriptive Statistics compared with American Community Survey

	Purchase (n = 1,954)	Lease (n = 333)	5-year American Community Survey (2019)
Income- Less than \$100,000	15.04%	23.51%	62.29%
Income- \$100,000 - \$199,000	52.76%	51.79%	25.56%
Income- More than \$200,000	32.19%	24.70%	12.16%
Single Family home	78.45%	71.13%	57.92%
Home ownership	82.08%	72.91%	54.65%
Gender - male	77.73%	70.83%	49.7%
Household vehicles- no vehicles	0%	0%	8.6%
one vehicle	18.2%	17.6%	32.7%
two vehicles	51.4%	54.5%	37.2%
three or more vehicles	30.4%	27.8%	21.4%
Household members	2.77 (1.23)	2.92 (1.25)	3.01 (1.56)
Age- 39 or younger	32.28%	29.16%	
40 to 59	42.01%	48.81%	
60 or older	25.33%	22.02%	

Table 3. Average sample vehicle characteristics by finance method

	Purchase (n = 2,583)	Lease (n = 442)
PEV Type - BEV	81.11%	60.80%
Electric range - BEV	249.0 (95.4)	130.8 (74.9)
Electric range- PHEV	35.9 (19.7)	34.8 (18.5)
Federal tax discount (as % of price)	11.0 (4.3)	41.3 (21.3)
Finance year 2019 or later	79.5%	51.4%
MSRP (\$)	44,138 (12,560)	34,651 (6,471)
Lease contract length (months)		36.3 (3.77)

Results

The results of the two MNL regression models for lessees and purchasers are shown in Table 5 and Table 6 respectively. Results are presented in the form of odds-ratio, which measures the odds of changing adoption behavior in the absence of the federal tax credit. An odds ratio of less than 1 represents a negative correlation and an odds ratio of more than 1 represents a positive correlation with the probability of choosing one of the alternatives relative to leasing a PEV, or purchasing the same PEV.

Vehicle and contract characteristics

For the lease model, the discount percent is positive and significant for choosing no vehicle; lessees are 1.020 times as likely not to lease any vehicle at all than to lease a PEV. For the purchase model, the discount ratio is positive and significant for all choice alternatives; as the discount percent increases, purchasers are more likely to choose another PEV, no vehicle, or a conventional vehicle, than to not change their purchase decision. Results of the purchase model show that the likelihood of purchasing a conventional vehicle or another PEV, rather than the same PEV, decreases as the electric range of BEVs increases. The year in which the PEV was leased/purchased also has significant effects. Results of the lease model show that relative to 2018, lessees in 2019 are 0.224 times as likely to purchase/finance the PEV than to lease a PEV. Results of the purchase model show that relative to 2018, purchasers in 2019 are 1.239 times as likely to purchase a conventional vehicle, and 1.456 times as likely to purchase another PEV than to purchase the same PEV. Additionally, the lease contract length has a positive and significant effect for lessees choosing not to lease any vehicle; for a one-month increase in the contract length, lessees are 1.073 times as likely to not lease any vehicle at all than to lease a PEV. Lastly, the effect of MSRP is not statistically different from zero for any of the choice alternatives for either model.

Socio-demographics and household characteristics

Results of the lease model show that homeowners are 0.382 times as likely than renters to lease a conventional vehicle than to lease a PEV. Males are also 1.556 times as likely than non-males to lease a conventional vehicle than to lease a PEV. For purchasers, males are 1.273 times as likely than non-males to purchase no vehicle than to purchase the same PEV. In regard to

age, results from the lease model show that older lessees are more likely to purchase/finance the PEV, rather than leasing a PEV. For purchasers, results show that age has a negative and significant effect for all choice alternatives relative to no change; younger purchasers are more likely than older purchasers to change their purchase decision to another PEV, no vehicle, or a conventional vehicle, than to purchase the same PEV. Lastly, results of the lease and purchase model show that the likelihood of leasing/purchasing no vehicle rather than leasing a PEV/purchasing the PEV increases by 2.358 and 1.470 times, respectively for a one unit increase in the number of vehicles available per driver.

Table 4. MNL regression results for lessees for change in finance decision in absence of federal tax credit. The reference group is leasing a PEV

	Purchase/finance PEV		No vehicle		Conventional	
	Estimate	Robust t-ratio	Estimate	Robust t-ratio	Estimate	Robust t-ratio
Alternative specific constant	6.598	0.7792	0.021 **	-2.0287	3.706	0.7014
BEV dummy	35.215	1.1315	2.156	0.6761	5.098	1.1174
Home ownership dummy	0.496	-1.0889	0.657	-1.1830	0.382 ****	-3.1331
Male dummy	0.780	-0.4944	1.081	0.2774	1.556 *	1.8597
Age	1.031 *	1.7282	1.000	-0.0143	0.991	-0.9048
Discount percent	0.961	-1.5336	1.020 **	1.9853	1.004	0.4242
Electric range x BEV	0.978	-1.1929	1.000	0.0838	0.998	-0.6612
Electric range x PHEV	0.997	-0.0834	1.007	0.3407	1.027	1.1012
MSRP	0.944	-0.1815	1.016	0.0868	0.797	-1.2254
Vehicles per driver	2.195	1.3122	2.358 ***	3.1460	1.061	0.1693
Finance year-2019	0.224 **	-2.5265	1.123	0.3656	1.028	0.1012
Lease contract length	0.930	-1.6279	1.073 *	1.7834	0.992	-0.2005

Statistical significance: 0 '****' 0.001 '***' 0.01 '**' 0.05 '*' 0.1

Table 5. MNL regression results for purchasers for change in purchase decision in absence of federal tax credit. The reference group is purchasing the same PEV.

	Another PEV		No vehicle		Conventional	
	Estimate	Robust t-ratio	Estimate	Robust t-ratio	Estimate	Robust t-ratio
Alternative specific constant	0.128 ***	-3.455	0.242 ***	-3.037	0.774	-0.529
BEV dummy	2.008	1.359	1.410	0.797	0.861	-0.318
Home ownership dummy	0.865	-0.701	1.147	0.955	0.808	-1.437
Male dummy	0.848	-1.024	1.273 *	1.973	1.009	0.068
Age	0.985 **	-2.834	0.976 ****	-6.380	0.978 ****	-5.450
Discount percent	1.139 ****	6.783	1.110 ****	6.732	1.134 ****	8.112
Electric range x BEV	0.997 *	-1.737	1.001	0.157	0.997 *	-1.762
Electric range x PHEV	1.013	1.540	1.000	1.398	0.997	1.085
MSRP	1.007	1.001	1.011	0.232	1.009	0.250
Vehicles per driver	1.499	0.750	1.471 ***	3.245	0.831	-1.150
Finance year-2019	1.456 **	2.267	1.060	0.457	1.239 **	2.013

Statistical significance: 0 '****' 0.001 '***' 0.01 '**' 0.05 '*' 0.1

Table 6. Model information

	num. obs.	Estimated parameters	Final log-likelihood	AIC
Lease	442	48	-711.37	1295.3
Purchase	2583	33	-3580.8	6279.47

Discussion

The results of the models reveal useful insights into how lease and purchase behavior may change in the absence of the federal tax credit. Historically this was relevant as tax credits phased out for Tesla and Chevrolet as they passed 200,000 PEV sales in the USA. More recently this is relevant due to the introduction of rules on where PEV batteries are made, vehicle purchase price caps, and income caps for buyers, which may reduce the number of eligible PEVs and PEV buyers that can receive a tax credit. It is therefore critical to understand how this could impact the PEV lease and purchase market differently, especially considering the differences in how the federal tax credit is administered depending on finance method (at least until 2024 where buyers may be able to transfer the credit to a dealer to receive it at the point of payment). According to Edmunds, for example, PEV leasing could be a way to circumvent the new restrictions on income eligibility, since dealerships own leased vehicles (26). We find that

several vehicle characteristics such as the discount percent from the tax credit, and the year in which it was financed, in addition to socio-demographics and household characteristics such as age, and home ownership are associated with consumers' decision to change their PEV adoption decision in the absence of the tax credit.

Contract characteristics

Our findings indicate that as the discount percent from the federal tax credit increases, the probability of not leasing or purchasing any PEV at all increases. These findings indicate that the federal tax credit supports the adoption of PEVs and encouraged respondents to lease or purchase a PEV. This aligns with results from stated preference studies such as Tal et al. (2), which attributes more than 30% of PEV sales in the U.S. to the federal tax credit, as well as revealed preference studies such as Jenn et al. (27), which attributes a 2.6% increase of PEV sales in the U.S. for every \$1,000 offered as a financial incentive. Additionally, this finding of lessees choosing not to lease any vehicle at all contributes to the literature which finds that consumers prefer financial incentives which are received at the time of payment rather than later (Gong et al., 2020; Hardman & Tal, 2016; Roberson & Helveston, 2022). This is the case for lessees who receive immediate benefits from the federal tax credit in the form of lower down and monthly payments. Previous literature has also found that favorable lease terms are associated with consumers deciding to lease, rather than purchase a PEV, further demonstrating the effectiveness of discounted lease contracts in driving the PEV lease market (9). We hypothesize that purchasers choosing another PEV in the absence of the tax credit may do so to finance a more affordable PEV. However, respondents were not asked which PEV they would choose in this case.

Vehicle characteristics

Our results for the interaction variable for purchased BEVs and electric range indicates that longer range BEV adopters decisions are less dependent on incentives than lower range BEVs, with purchasers less likely to switch from a higher range BEV to a conventional vehicle or another PEV in the absence of the tax credit. This aligns with other findings which have found consumers to prefer higher range BEVs (28).

Our results indicate that the importance of the tax credit may have increased for purchasers from 2018 to 2019. We find that in this time span, in the absence of the tax credit, the probability of purchasing a conventional vehicle rather than a PEV increases. This result aligns with results from Jenn et al. (3), which found from 2015 to 2018 that purchasers were more likely to purchase a conventional vehicle, or no vehicle at all in the absence of the tax credit; the authors suggest that earlier adopters belong to a latent group of innovative consumers who would have adopted a PEV with or without an incentive. However, we also find that the probability of purchasing another PEV, rather than the same PEV, increases in 2019. This result could reflect the wider variety of PEVs available on the market in that time span. We also find that the probability of lessees choosing to purchase, rather than lease the PEV decreases in 2019. We hypothesize this could be due to the generally lower upfront cost of leasing compared to purchasing, even without the federal tax credit. This could also support previous

research which found PEV leasing to be increasing over time (9). Future research should explore PEV lease behavior over time, such as if consumers continue with PEV technology once the lease term has ended, and if they exhibit PEV lease loyalty, or the tendency to lease a PEV if they have previously leased one, as is the case for the ICEV market.

Socio-demographics and household characteristics

Our results show that in the absence of the tax credit, renters are more likely than home owners to lease a conventional vehicle rather than a PEV. This finding contributes to the literature which finds home ownership and access to charging at home to be associated with PEV adoption. Davis (29) explored PEV ownership in the United States and found that even after controlling for income, homeowners are three times as likely to own a PEVs than renters; authors conclude that renters may have less access to a reliable parking spot and less incentive to invest in home charging equipment. A report by Nicholas et al. (30) additionally found that more than half of the PEV owners charged only at home, while just 14% charged solely from workplace or fast charging opportunities. Hardman and Tal (31) examined PEV discontinuance in California and found that inconvenience of charging and not having access to level 2 charging at home was associated with PEV discontinuance. Lessees without access to home charging may therefore discontinue PEVs if access to charging was a disadvantage to them. As the PEV market shifts from predominantly high-income families to middle income renters, more efforts will be needed to increase charging access for renters who may not be able to install charging infrastructure at home.

We also find that having more household vehicles per driver increases the probability of not leasing or purchasing a PEV at all; we hypothesize that consumers making this choice could have other vehicles in their household to meet their travel demand, and perhaps are retaining their older vehicles. Lastly, our finding of older purchasers being less likely to change their PEV purchase decision varies with stated preference studies which find older age to be negatively correlated with PEV adoption (11). Our finding of males being more likely to lease no vehicle, or purchase a conventional vehicle also varies from studies which find being male to be associated with PEV adoption (32).

Conclusion

This research explores the impact of the federal tax credit on PEV adoption using stated choice data of PEV owners in California. A novel addition to the existing field of research is the explicit consideration of purchasers and lessees, as there is a limited understanding of how the phasing out of the federal tax credit will affect the PEV lease market. We attempt to fill this gap in the research by specifying two separate MNL regression models for lessees and purchasers, both controlling for vehicle and contract characteristics, socio-demographics, and household characteristics. Our findings indicate that changes to federal tax credit eligibility could have an impact on California's goal of reaching 100% ZEV sales by 2035. Both purchased and leased PEVs will be needed in order to reach this goal; our findings demonstrate that without the federal tax credit, both purchasers and lessees are more likely not to finance a PEV at all. Since PEV leasing increases the turnover of PEVs entering the used PEV market, the absence of the

tax credit could also have a negative impact on the variety and supply of PEVs available in the used PEV market. While there is limited research on the used PEV market, it is thought that it could serve a similar function as does the used ICEV market, increasing access to PEVs to lower- and middle-income consumers. Lastly, this research contributes to the literature which finds home ownership to be associated with PEV adoption, with the novel distinction of finding homeownership to be associated with leasing a PEV rather than a conventional vehicle in the absence of the tax credit.

Limitations and future research

As with any choice-based study, our results are likely influenced by sample bias; the respondents represent the population of PEV owners in California who are CVRP recipients. Therefore, the results of this analysis cannot be extended to the general population of PEV owners. Another limitation is the exclusion of Tesla and Chevrolet lessees, due the uncertainty of the tax credit discount during the incentive phase-out period. Lastly, Future research aims to jointly model the impact of the federal tax credit on the decision to purchase or lease a PEV, and the subsequent adoption choice made in the absence of the tax credit. Results of the lease and purchase models also show that the likelihood of not leasing or purchasing a PEV increases as there are more household vehicles available per driver. The federal tax credit therefore may encourage buyers to adopt a PEV when they weren't considering a new vehicle, accelerating the retirement of non-ZEVs. This is important as the slow vehicle turnover of on road vehicles is a barrier to achieving the emissions reductions possible from PEV technology and meeting emissions reductions targets. Dimanchev et al. (33) found that decreasing the average historic vehicle lifetime from 16 to 12 years would increase ZEV fleet share in 2050 by 8%. However future research should explore if PEVs are replacing household vehicles, and what happens to the replaced vehicle. Additionally, future surveys could capture shifts in demographic characteristics in response to the changes in incentive eligibility, and a supply constrained vehicle market.

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Data Summary

Products of Research

We use results from a cohort survey of electric vehicle owners in California conducted in 2019. The respondents of the survey are sampled from the pool of California Clean Vehicle Rebate Project (CVRP) recipients, a rebate program for purchasers and lessees of electric vehicles within California. The CVRP is administered by the Center for Sustainable Energy & California Air Resources Board, who have an agreement with the University to provide contacts (e-mail) for solicitation for the purposes of disseminating and gathering respondents for the survey. Altogether, phase 5 include 7,078 respondents, all of whom have applied for the CVRP rebate following the purchase or lease of a PEV.

Data Format and Content

The data is separated by purchasers and lessees, since they are modeled separately. There is a data dictionary for the variables used in the analysis

Data Access and Sharing

The data used for this research can be accessed at: <https://doi.org/10.25338/B8M06B>

Reuse and Redistribution

Data can be reused and redistributed providing the original data source is cited:

Hoogland, Kelly; Hardman, Scott; Chakraborty, Debapriya; Bunch, David (2023), Exploring impact of federal tax credit on decision to lease or purchase a PEV, Dryad, Dataset, <https://doi.org/10.25338/B8M06B>

Appendix

Table 7 provides the distribution of makes and models in the pre-screened and screened sample. In our final sample used for analysis, the Nissan Leaf, Honda Clarity BEV and Clarity PHEV have the highest lease rate for the screened sample. The Tesla Model 3 accounts for more than half of the screened purchase sample. The Prius Prime and Chevrolet Bolt have the next highest purchase rates, although neither account for more than 7% of the sample. The proportion of PEVs available for purchase or lease is influenced by automobile manufacturers' strategic decisions, and therefore varies from one automaker to another. California based automakers in particular could also use a lease strategy to catalyze their trajectory for meeting the states' ZEV mandate. In 2022, special lease incentives were offered by Ford and Fiat Chrysler for the Ford Mustang Mach-E and Jeep Grand Cherokee respectively, while Ford incentivized the financing option for makes such as the Escape Hybrid through attractive deals such as 0% APR for 60 months.

Table 7. Percent of makes/models in pre-screened and screened sample by finance method

	Lease		Purchase	
	Pre- screen (n = 1,121)	Screened (n = 521)	Pre-screen (n = 5,079)	Screened (n = 2,665)
Fiat 500e	3.84	7.10	0.08	0.11
Chevrolet Bolt EV	19.54	0.00	6.54	6.83
Honda Clarity Electric	6.16	10.75	0.10	0.04
Honda Clarity PHEV	8.56	15.74	4.86	5.52
Volkswagen e-Golf	4.73	8.83	1.67	2.03
Audi e-tron	1.07	1.92	0.24	0.23
Smart EQ fortwo	1.96	3.26	0.04	0.04
Ford Fusion Energi	4.73	6.53	0.55	0.30
Hyundai Ioniq Electric	3.12	5.37	0.10	0.19
Hyundai Ioniq Plug-in Hybrid	0.54	0.96	1.00	0.98
Hyundai Kona EV	1.61	2.50	1.08	1.20
Nissan Leaf	9.37	16.89	3.03	3.30
Tesla Model 3	7.49	0.00	60.41	62.59
Tesla Model S	0.98	0.00	2.89	2.25
Tesla Model X	1.43	0.00	2.72	2.14
Kia Niro EV	1.52	2.88	0.61	0.68
Kia Niro Plug-In Hybrid	4.01	7.49	1.24	1.28
Mitsubishi Outlander PHEV	1.07	1.92	0.43	0.26
Pacifica Hybrid	0.54	0.77	1.38	1.69
Prius Prime	1.52	1.92	7.66	5.67
Volt	12.76	0.00	2.15	1.95

Figure 5 shows the difference between the imputed and participant-reported credit amounts. The imputed values are the maximum eligible credit amount based on battery size and model year. Negative values represent stated credit amounts that were larger than the imputed credit amount, and positive values represent stated credit amounts that were smaller than the imputed values. As seen for the maximum credit amount, \$7,500, participants could report receiving lower credit amounts due to having lower tax liability. Alternatively, during the tax credit phase-out for Tesla, when the maximum eligible credit was \$1,875, participants report receiving more than this amount.

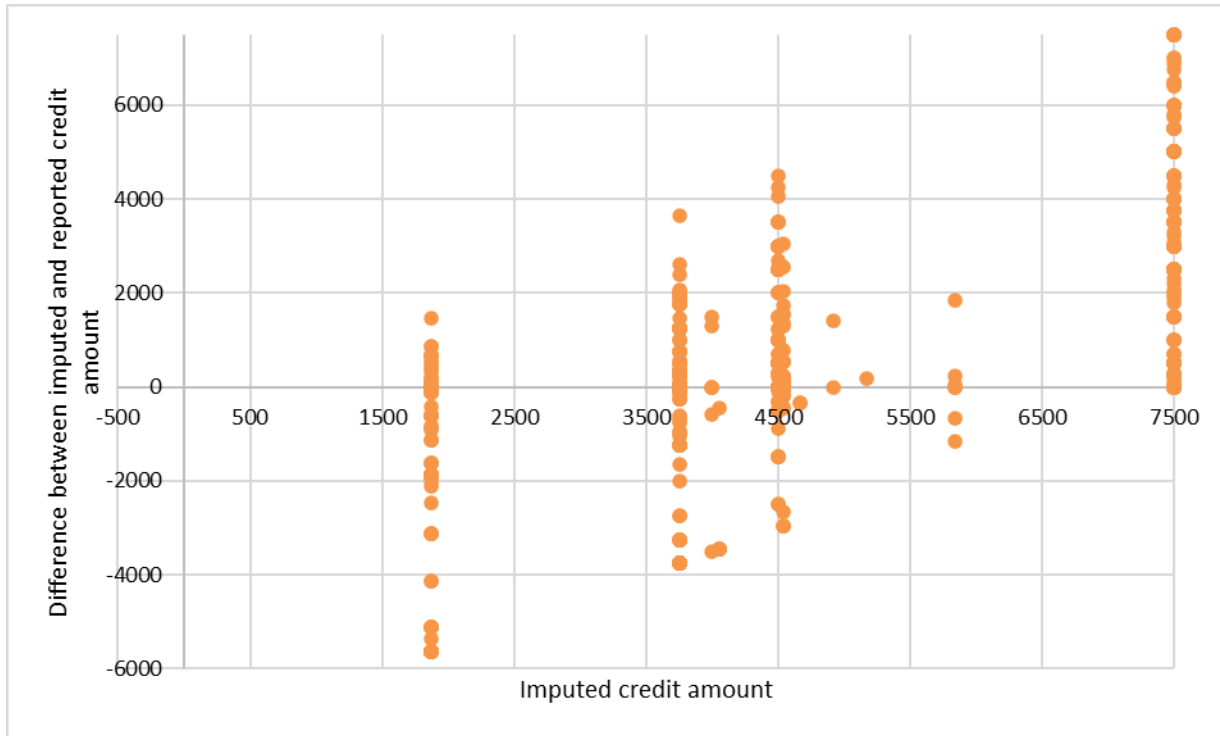


Figure 5. Difference between imputed and stated credit amounts received