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HOW INCENTIVE DESIGN SHAPES PASS-THROUGH: EVIDENCE FROM THE U.S. ELECTRIC VEHICLE MARKET



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How Incentive Design Shapes Pass-Through: Evidence from the U.S. Electric Vehicle Market[*]

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Abstract

We study the pass-through of U.S. state electric vehicle incentives using transaction-level data and a newly assembled dataset of state programs from 2012–2020. Average pass-through is approximately full, but this aggregate estimate conceals substantial heterogeneity. We find that pass-through varies sharply across program designs and buyer characteristics. Transaction prices decrease for purchases and point-of-transaction incentives, resulting in more than full pass-through, while for leases, incentives are substantially eroded by higher transaction prices. Pass-through also varies non-monotonically with buyer income, with no evidence that higher-income buyers capture a larger share of the marginal incentive dollar.

Résumé

Nous étudions la répercussion des mesures incitatives mises en place par les États américains pour l'achat de véhicules électriques, à partir de données individuelles sur les transactions et d'une nouvelle base de données regroupant les programmes des États pour la période de 2012 à 2020. En moyenne, les mesures incitatives sont répercutées presque intégralement sur les prix payés par les consommateurs, mais cette estimation globale masque d'importantes différences. Nous constatons que le degré de répercussion varie considérablement selon la conception des programmes et les caractéristiques des acheteurs. Les prix de transaction diminuent pour les achats de véhicules et lorsque les mesures incitatives sont appliquées au moment de la transaction, ce qui entraîne une répercussion supérieure à 100 %. En revanche, dans le cas des locations, une hausse des prix de transaction absorbe une part importante des avantages procurés par les mesures incitatives. La répercussion varie également de manière non monotone selon le revenu des acheteurs, sans que les résultats indiquent que les acheteurs à revenu élevé bénéficient d'une plus grande part de chaque dollar supplémentaire d'incitatif.

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1 Introduction

Purchase incentives are among the most widely used tools of economic policy. Governments subsidize health insurance, housing, food, home energy improvements and clean vehicles, for reasons that range from correcting externalities and supporting nascent industries to redistributing income and stimulating demand during economic downturns.[1] These objectives differ, but each depends on how the subsidy is shared between the consumer and the seller, a division that governs both the behavioral response the policy induces and its distributional consequences. When the good or service is provided by a market, that division is determined in equilibrium, not by the statute. It depends on the elasticity and curvature of demand and on the degree of competition among sellers (Bulow and Pfleiderer, 1983; Kotlikoff and Summers, 1986; Weyl and Fabinger, 2013), but also on how the program is structured. Policymakers must decide who qualifies, how the payment is delivered, and which transactions are eligible. Each of these choices may affect how much of the incentive reaches the consumer.

In this paper, we study how the design of a consumer purchase incentive affects its pass-through to consumer prices. Our setting is the U.S. market for new electric vehicles (EVs), where state-level incentives varied widely in both generosity and design.[2] We first estimate the pass-through rate of U.S. state-level EV incentives from 2012 to 2020, that is, how much of each incentive dollar reaches the consumer. We then examine how pass-through varies with the design choices that policymakers face in structuring these programs: whether the incentive is delivered at the point of sale or claimed after the purchase and whether purchases and leases qualify equally. Each of these choices corresponds to a design margin along which state incentives differ. We also estimate how pass-through varies with buyer income. These programs are frequently criticized for disproportionately benefiting higher-income households, a criticism that concerns *who* receives the incentive (Borenstein and Davis, 2016, 2025). Whether the marginal incentive dollar also accrues disproportionately to higher-income households is a distinct and equally important question, and one that our pass-through estimates can answer. Estimating all of these dimensions in a unified dataset with a common empirical design allows us to compare them directly.

The economic stakes of these design choices are considerable. Global government spending on

[1] Examples include premium subsidies in the Affordable Care Act Marketplaces (Polyakova and Ryan, 2021), Housing Choice Vouchers in the U.S. (Collinson and Ganong, 2018), temporary transaction tax cuts in the U.K. (Best and Kleven, 2018), and subsidies for residential solar installation (Pless and Van Benthem, 2019).

[2] For the purposes of this research, we use the term EV to refer to plug-in electric vehicles which include plug-in hybrid electric vehicles (PHEVs) and battery-only electric vehicles (BEVs).

EV incentives (including foregone revenue due to tax waivers) exceeded $40 billion in 2024 (International Energy Agency, 2025), and the U.S. federal tax credit alone cost over $2 billion in that same year (U.S. Department of the Treasury, 2024). State programs are also substantial: California's Clean Vehicle Rebate Project distributed roughly $1.5 billion over its lifetime (California Air Resources Board, 2023) and the Massachusetts MOR-EV program over $150 million (Massachusetts Department of Energy Resources, 2025). The design of state-level incentives has also become more consequential over time. The federal tax credit for EV purchases and leases ended in 2025 (Internal Revenue Service, 2025), and U.S. EV sales fell by 20 percent to 36 percent year-over-year in the quarters that followed the credit's expiration (Cox Automotive, 2026). With federal support withdrawn, state programs are now the primary policy instrument supporting EV adoption in the U.S., and several states have responded by introducing or restructuring their own incentives. For example, Colorado expanded its rebate program within weeks of the federal tax credit's expiration (Colorado Energy Office, 2025) and California announced a $3,500 rebate restricted to first-time buyers in July 2026 (Shepardson, 2026). Empirical evidence on the pass-through of state-level EV incentives, their design, and their distributional consequences is therefore particularly timely.

To measure the pass-through of these incentives and how it varies with their design, our empirical analysis draws on transaction-level data covering new vehicle purchases and leases in the U.S. from 2012 to 2020, including the transacted price, the buyer's household income, and detailed vehicle characteristics. We combine these data with self-collected documentation of the eligibility rules and amounts of every state-level EV incentive over this period, which we use to assign each transaction the incentive it qualified for. We estimate pass-through from the relationship between the assigned incentive and the transacted price, controlling for vehicle, state and year-month fixed effects. Identification comes from the wide variation in incentive design and generosity, which resulted in awards that varied within vehicles across states and within states over time.

Our first result is an estimate of average pass-through across all state programs and transactions. Our preferred estimate implies a pass-through rate of about 100 percent: each $1,000 of incentive lowers the price the consumer pays by roughly $1,000, on average. Our estimates do not reject full pass-through, implying that consumers capture the entirety of the incentives on average. The estimate is stable across specifications and alternative approaches to inference. To our knowledge, this is the first estimate covering the full set of U.S. state programs over an extended period.

A natural question is whether this aggregate figure conceals variation across the design choices that generate it. We first examine whether pass-through differs by delivery method, that is, whether

the incentive is delivered at the point of transaction or claimed afterwards. If consumers optimize fully with respect to the incentives they face, the timing and form of the payment should not matter for incidence. Chetty et al. (2009) show, however, that consumers under-react to components of price that are not salient at the time of the decision, and that economic incidence then depends on statutory incidence.[3] Bradley and Feldman (2020) provide empirical evidence of this mechanism. When U.S. regulators required airlines to include taxes in advertised fares, pass-through of those taxes to consumers fell sharply, and fell most in more concentrated markets. Kroft et al. (2024) demonstrate that how this salience effect translates into pass-through depends on the market structure. Applied to our setting, an incentive claimed after the transaction should generate a more muted demand response and leave the equilibrium price largely unchanged, so that pass-through remains close to 100 percent. An incentive applied at the point of transaction, by contrast, generates a larger equilibrium price response, moving pass-through further from 100 percent.[4] Our estimates are consistent with this intuition. Pass-through is about 91 percent under post-transaction delivery, 127 percent under point-of-transaction delivery, and 92 percent where programs offer buyers the choice. Point-of-transaction pass-through is significantly higher than pass-through under either post-transaction delivery or buyer choice, while the latter two are not statistically distinguishable.

We next examine whether pass-through differs between purchases and leases. Pass-through depends on the curvature of demand and the degree of competition among sellers (Weyl and Fabinger, 2013), and these can differ between the purchase and lease segments of the same market. In one setting where the comparison has been estimated within a single program, residential solar, pass-through differs sharply between buyers and lessees of the same product, with over-shifting for lessees rather than buyers (Pless and Van Benthem, 2019). Pass-through differs significantly between purchases and leases in our setting as well. For purchases, we estimate pass-through of 118 percent and reject full pass-through in favor of over-shifting. For leases, pass-through is substantially lower, at about 60 percent, and we reject full pass-through in favor of incomplete pass-through. The contrast between the two segments is therefore substantial: consumers receive more than the statutory incentive amount when purchasing a vehicle but only about three-fifths of it when leasing. The

[3] Salience effects have been documented for sales and excise taxes (Chetty et al., 2009; Goldin and Homonoff, 2013; Feldman and Ruffle, 2015; Feldman et al., 2018; Bradley and Feldman, 2020), tolls (Finkelstein, 2009), and tax credits (Chetty and Saez, 2013; Feldman et al., 2016).

[4] In general, a salient incentive shifts demand by the full amount of the incentive, and the resulting price response moves pass-through away from 100 percent in either direction. In a competitive market with upward-sloping supply, the price rises and the seller captures part of the incentive, so pass-through falls below 100 percent. In a market with over-shifting, the price response works in the consumer's favor and pass-through rises above 100 percent. A non-salient incentive barely shifts demand, so the price hardly moves and pass-through stays near 100 percent in either case.

near-full pass-through we estimate on average masks these sharply different incidence patterns across purchases and leases. Since leases account for about 40 percent of EV transactions in states offering incentives, any difference between the two rates applies to a substantial share of transactions. These results also have important implications for policy design. Extending eligibility to leases broadens the reach of the program, since leases would otherwise be ineligible for the incentive. At the same time, the estimates show that equal eligibility need not produce equal effects, with each incentive dollar reducing consumer prices by substantially more when it applies to a purchase than when it applies to a lease.

Finally, we examine how pass-through varies with buyer income and find significant differences across income groups, with a pattern that is not monotone. Pass-through falls from about 130 percent for the lowest-income group to 72 percent for middle-income households, before returning to approximately 100 percent for the two highest-income groups. The resulting U-shaped pattern implies that the lowest-income buyers receive more than the full statutory incentive, the middle of the income distribution receives less, and pass-through returns to approximately full pass-through among higher-income buyers. Thus, although EV incentives may disproportionately go to higher-income households because of who purchases EVs, we find no corresponding tendency for the marginal incentive dollar to be passed through more strongly to higher-income buyers. Such non-monotone pass-through patterns have been documented in other markets as well. For example, Harding et al. (2012) find a comparable U-shape in cigarette excise tax pass-through across education groups, with the highest rates for the least and the most educated households and lower rates in between. Closer to our work, prior literature on the EV market has estimated pass-through by income only for a program restricted to low- and middle-income households in California, finding rates somewhat below our estimates for the lowest income groups, though neither rules out full pass-through (Muehlegger and Rapson, 2022). Our estimates, by contrast, cover all state EV incentives and the full income distribution, allowing us to assess whether pass-through under a widely implemented program differs from that of a targeted pilot. Taken together, these results show that near-full pass-through on average masks substantial differences in incidence across program design and buyer characteristics.

Our paper contributes to the literature on pass-through and incidence of taxes and subsidies. A long line of work shows that the division of a tax or a subsidy between buyers and sellers depends on the shape of the demand curve and the intensity of competition (Bulow and Pfleiderer, 1983; Kotlikoff and Summers, 1986; Weyl and Fabinger, 2013). More recent studies document that pass-

through also depends on the salience of the instrument (Chetty et al., 2009; Bradley and Feldman, 2020; Kroft et al., 2024) and that it can vary widely across consumer groups within the same market (Harding et al., 2012; Polyakova and Ryan, 2021). More specifically, our work contributes to the estimation of incentive pass-through in the vehicle market (Busse et al., 2006; Sallee, 2011; Gulati et al., 2017; Muehlegger and Rapson, 2022; Allcott et al., 2024; Duong and Weber, 2024; Remmy, 2026).[5] Most of these studies find that buyers capture the majority of incentives directed to them, typically between 70 and 100 percent (Busse et al., 2006; Sallee, 2011; Muehlegger and Rapson, 2022; Allcott et al., 2024; Duong and Weber, 2024).[6] To our knowledge, the literature has not established whether the variation in findings across these papers reflects differences in incentive design or other unobserved features of their settings. [7] Our contribution to this literature is to provide an estimate that covers the entire U.S., every state-level incentive program, and a long time span over which the EV market grew from its infancy into an established segment. In aggregate, we cannot reject full pass-through, consistent with the upper end of the range in prior work. Within this single market and empirical design, however, pass-through ranges from about 60 percent for leases to over 125 percent for incentives applied at the point of transaction, a spread comparable to that found across separate studies.[8] Differences in program design can therefore generate much of the variation documented in the literature. We also show that pass-through varies with buyer income.

Our paper also complements prior work on the design of public programs, which studies how a program's effects depend on the conditioning of its transfer (Rothstein, 2010), the cost of claiming it (Kleven and Kopczuk, 2011), the structure of its generosity (Collinson and Ganong, 2018), the attribute on which eligibility is based (Ito and Sallee, 2018; Barwick et al., 2024), the placement of its thresholds (Best and Kleven, 2018), and the population it targets (Polyakova and Ryan, 2021). Each of these papers examines a single design margin, in a different program and market from

[5]Beyond pass-through, a large literature evaluates the effects of EV incentives on adoption, including subsidies and tax incentives (Gallagher and Muehlegger, 2011; Li et al., 2017; Jenn et al., 2018; Yan and Eskeland, 2018; Clinton and Steinberg, 2019; Springel, 2021; Muehlegger and Rapson, 2022; Haan et al., 2025) and local incentives such as exemptions from tolls and congestion pricing (Mersky et al., 2016; Isaksen and Johansen, 2021) or access to HOV lanes (Sheldon and DeShazo, 2017; Avis et al., 2025; Halse et al., 2025).

[6]The exceptions arise in specific settings: payments directed to dealers are largely retained by dealers (Busse et al., 2006; Duong and Weber, 2024), and buyers in Canada used part of a sales-tax rebate to purchase additional options (Gulati et al., 2017).

[7]Barwick et al. (2023) instead compare thirteen countries, but consider only central and federal incentives and measure prices by manufacturer list price.

[8]Our point-of-transaction estimate exceeds the 73 to 85 percent found for point-of-sale rebates by Muehlegger and Rapson (2022) and Duong and Weber (2024), who study a single regional pilot program and a single state's program, respectively, whereas our estimate pools several statewide programs.

the others, so their estimates do not permit direct comparisons across margins. We contribute to this literature by bringing several of these margins into one setting. Observing them within a single market, dataset, and empirical strategy allows us to compare the pass-through of differently designed incentives on a common outcome.

The paper proceeds as follows. Section 2 describes the state incentive programs and the data. Section 3 outlines the theoretical framework for pass-through. Section 4 presents the empirical strategy. Section 5 reports pass-through estimates for the market as a whole and examines how pass-through varies with program design and with buyer characteristics. Section 6 concludes.

2 Data and Policy Background: EV Market and State-Level Incentives

We combine transaction-level data on new vehicle purchases and leases with a newly assembled database of state EV incentive programs. The transaction data provide prices consumers pay, financing decisions, buyer demographics and detailed vehicle characteristics. The policy data record program amount and eligibility rules over time, allowing us to determine the state incentive for which each transaction was eligible between January 2012 and September 2020. We first describe the vehicle transaction data and then the state incentive programs.

2.1 Vehicle Transaction Data

Our primary source of transaction data is the New Vehicle Customer Study (NVCS; Ipsos, 2012-2020), currently owned by Ipsos and previously administered by MaritzCX and InMoment. The NVCS is filled out by households that have recently purchased or leased a new vehicle. Our data contain approximately 1.95 million responses from January, 2012 to September, 2020. We describe below how we construct weights for these survey data to make them representative of the U.S. new vehicle market. Approximately 1.03 million responses remain in our estimation sample after excluding responses without a reported purchase price or household income, responses for which we could not match with registration weights, and responses that took place in Washington, DC.[9]

For each transaction, survey respondents report the transaction price of the newly obtained vehicle, including taxes and excluding the value of any trade-in, as well as whether the vehicle was

[9]Of the excluded responses, 72.51% lack a reported purchase price; an additional 25.13% lack reported household income; 2.21% cannot be assigned a registration weight; and 0.15% took place in Washington, DC. We exclude Washington, DC for consistency, as we do not track city-level programs for other major US cities. Moreover, the potential for DC residents to claim nearby state incentives made the assignment of their subsidy award ambiguous and the number of responses this exclusion affects is small.

purchased or leased along with detailed information on its financing and characteristics. The data also contain the vehicle identification number (VIN) and buyer demographics, including household income, age, education, and location of residence. A key advantage of the NVCS for our analysis is that it reports actual transaction prices rather than list prices. Transaction prices reflect the price agreed upon by the buyer and the seller and can therefore capture the equilibrium price response to an incentive.

We merge the NVCS with detailed vehicle characteristics from DataOne using a ten-character pattern constructed from the reported VIN (DataOne Software, 2020). These data provide the vehicle's manufacturer suggested retail price (MSRP) and fuel type, as well as battery capacity and electric range for plug-in vehicles. These characteristics are important for assigning state incentives because many programs condition eligibility or the incentive amount on vehicle attributes such as fuel type, battery capacity, range, or MSRP. We supplement DataOne's battery characteristics with the US Environmental Protection Agency's (EPA) Annual Fuel Economy Guides (US Environmental Protection Agency, 2020).

The NVCS does not sample vehicle models in proportion to their shares of the U.S. new vehicle market and oversamples several relatively low-volume vehicle segments, including alternative-fuel vehicles. Therefore, we reweight the survey data using two additional data sources. The Experian North American Vehicle Database covers the universe of U.S. new-vehicle registrations and provides registration counts by vehicle model (Experian, 2012–2020). We use these data to match the distribution of vehicle registrations in the NVCS to the U.S. market. We also use the Consumer Expenditure Survey (CEX; Bureau of Labor Statistics, 2020) to match the distribution of new vehicle buyers across household income groups. Because we do not observe the joint population distribution of vehicle choice and household income, we construct the weights using iterative proportional fitting. The resulting weighted NVCS simultaneously matches Experian vehicle registration counts by VIN group, state, and month and the annual income distribution of new-vehicle purchasers in the CEX.

Table 1 reports descriptive statistics separately for EV and non-EV transactions in states that offered a qualifying state incentive at some point during the sample period and states that did not. EV buyers are considerably more concentrated at the top of the income distribution than non-EV buyers in both groups of states. More than half of the EV transactions are associated with household incomes above $200,000, compared with 18.5 percent of non-EV transactions in incentive states and 12.3 percent in non-incentive states. Leasing also differs substantially across

groups: 39.3 percent of EV transactions in incentive states are leases, compared with 16.6 percent in states without an incentive.

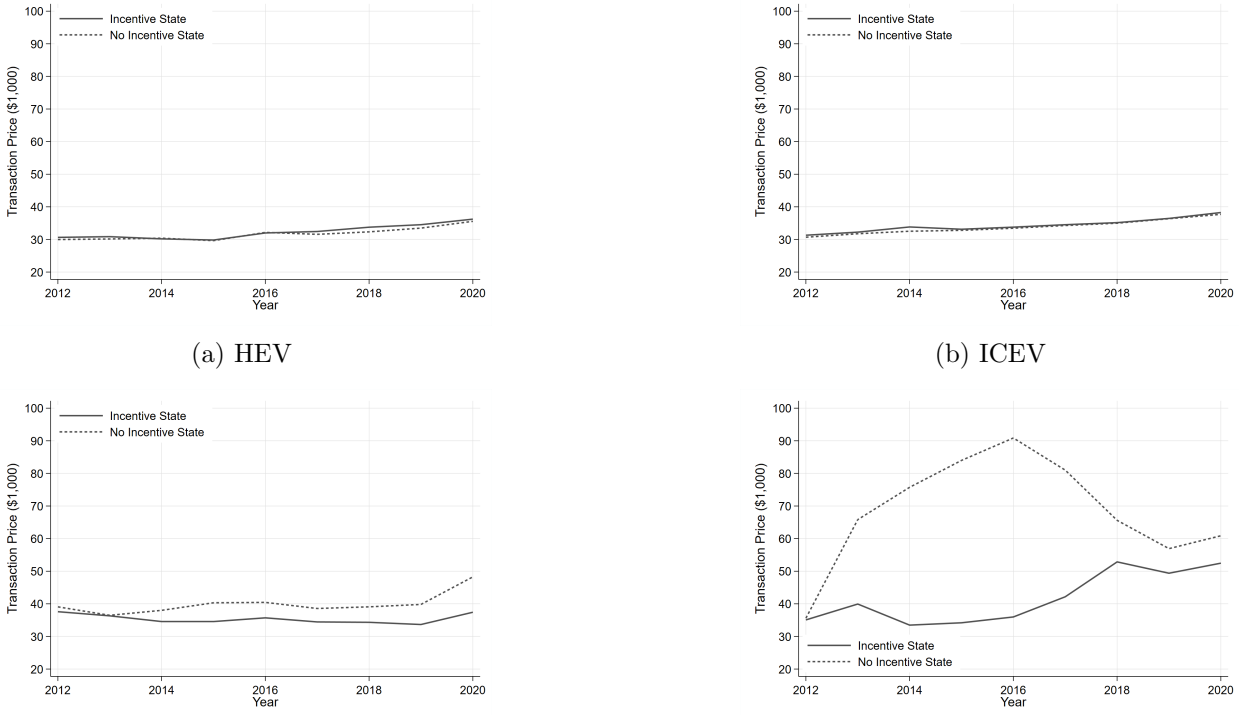
Table 1: New vehicle transaction samples in incentive and non-incentive states

	EV		Non-EV	
	Subsidy states	Non-subsidy states	Subsidy states	Non-subsidy states
Number of transactions	24,081	8,985	531,102	471,327
Avg. transaction price	$39,255	$56,854	$34,119	$33,789
Avg. subsidy	$1,701	$0	$0	$0
Leased share	39.3%	16.6%	22.0%	22.0%
Income share:				
Less than $45,000	8.0%	3.8%	19.3%	21.8%
$45,000–$85,000	8.6%	10.2%	23.7%	28.4%
$85,000–$125,000	12.0%	15.1%	19.8%	20.9%
$125,000–$200,000	18.3%	20.6%	18.7%	16.6%
$200,000+	53.2%	50.3%	18.5%	12.3%

Notes: This table reports descriptive statistics separately for EV and non-EV transactions in states that offered a qualifying state incentive at some point during the sample period and states that did not. EVs include BEVs and PHEVs; all other fuel types are classified as non-EVs. Transaction counts are unweighted. Averages and shares are weighted using the survey weights described in the text, which match vehicle registration counts from Experian and income distributions from the CEX. The subsidy amount is the state incentive for which each transaction is eligible.

For descriptive figures, we distinguish internal combustion engine vehicles (ICEVs), conventional hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). Figure 1 provides a first look at differences in the vehicles purchased in incentive and non-incentive states. Average transaction prices for ICEVs and HEVs evolve similarly across the two groups of states. The differences are larger for plug-in vehicles, particularly BEVs, for which the transaction prices are substantially higher in non-incentive states during much of the sample period. Figure A.1 for MSRPs across these fuel types displays similar patterns.

Figure 1: Average transaction price by fuel type and incentive-state status.



(a) HEV

(b) ICEV

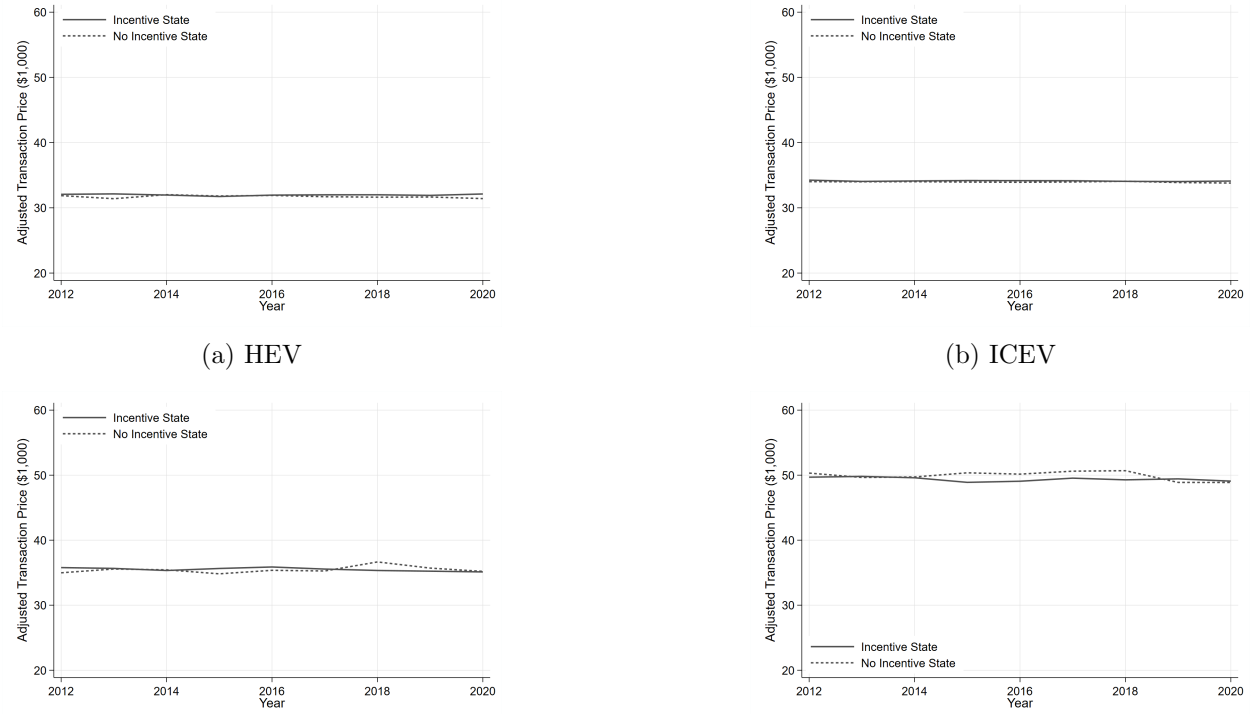
(c) PHEV

(d) BEV

Notes: This figure reports annual average transaction prices separately for internal combustion engine vehicles (ICEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). A state is classified as an incentive state if it offered a qualifying state vehicle incentive at any point during the sample period. Averages are weighted using the survey weights described in the text.

These differences partly reflect differences in the composition of vehicles purchased across states. Figure 2 therefore presents transaction prices after removing the weighted mean price of each VIN pattern and adding back the fuel-type average. These figures depict how transaction prices vary around the mean for each vehicle (as defined by VIN pattern) by incentive and no-incentive states, over time.

Figure 2: VIN-pattern-adjusted average transaction price by fuel type and incentive-state status.



(a) HEV

(b) ICEV

(c) PHEV

(d) BEV

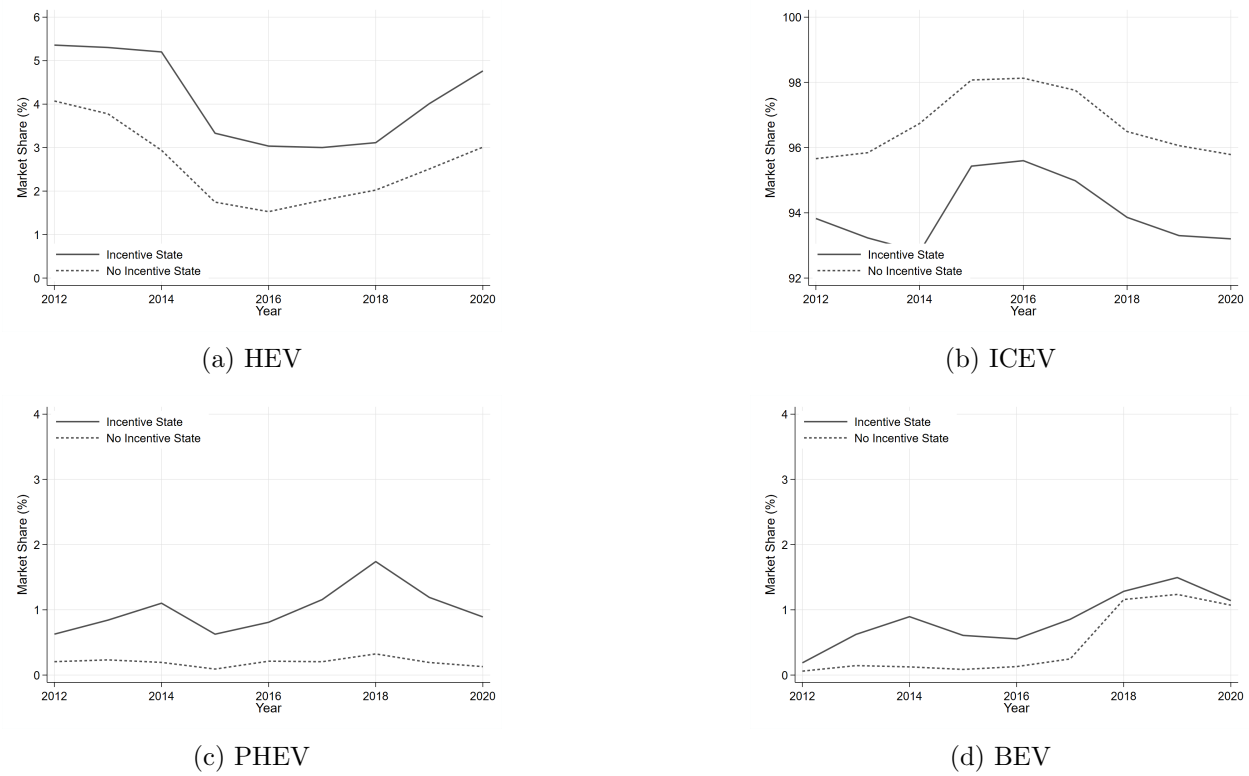
Notes: This figure reports annual average transaction prices separately for internal combustion engine vehicles (ICEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs), after adjusting for differences in vehicle composition. We subtract the weighted mean transaction price for each VIN pattern and add back the weighted mean transaction price for the corresponding fuel type. A state is classified as an incentive state if it offered a qualifying state vehicle incentive at any point during the sample period. Averages are weighted using the survey weights described in the text.

The resulting prices are substantially more similar across incentive and non-incentive states, indicating that differences in vehicle composition account for an important part of the unconditional price differences between the two groups. This descriptive comparison motivates the detailed vehicle fixed effects used in our empirical analysis.

Figure 3 shows corresponding differences in vehicle composition. PHEVs and BEVs generally account for larger shares of new-vehicle transactions in incentive states, whereas conventional vehicles account for a smaller share. These patterns are descriptive rather than causal, but they

illustrate the substantial differences in vehicle composition across the two groups of states.

Figure 3: Weighted transaction shares by fuel type and incentive-state status.



(a) HEV

(b) ICEV

(c) PHEV

(d) BEV

Notes: This figure reports annual transaction shares separately for internal combustion engine vehicles (ICEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). Shares are calculated separately within incentive and non-incentive states using the survey weights described in the text. A state is classified as an incentive state if it offered a qualifying state vehicle incentive at any point during the sample period.

2.2 EV Incentives

State EV incentive programs vary substantially in both generosity and design. Twenty-two states offered a qualifying vehicle incentive at some point between 2012 and 2020. These programs take several forms, including rebates, income tax credits, and exemptions from sales, excise, or use taxes. Incentive amounts are typically between $1,000 and $5,000, but the amount available to a particular buyer may depend on the vehicle's fuel type, battery capacity or electric range, MSRP, household income, and whether the vehicle is purchased or leased. Many of these rules also change within states over time.

We construct a comprehensive database of these programs by reviewing state government and program documentation, using the Alternative Fuels Data Center (AFDC) as a guide to identify relevant programs (Alternative Fuels Data Center, 2012–2020). For each program, we record its

start and end dates, the statutory incentive amount or formula, vehicle and buyer eligibility requirements, whether purchases and leases qualify, and how the incentive is delivered. We then combine these rules with the transaction date and buyer state in the NVCS, together with the buyer and vehicle characteristics that determine eligibility, to calculate the state incentive available for each transaction.

Some eligibility rules depend on buyer or transaction characteristics that are not reported for every observation, such as household income or lease length. Because these variables can determine both eligibility and the amount of the incentive, we exclude transactions for which missing information prevents us from determining the applicable state incentive.[10]

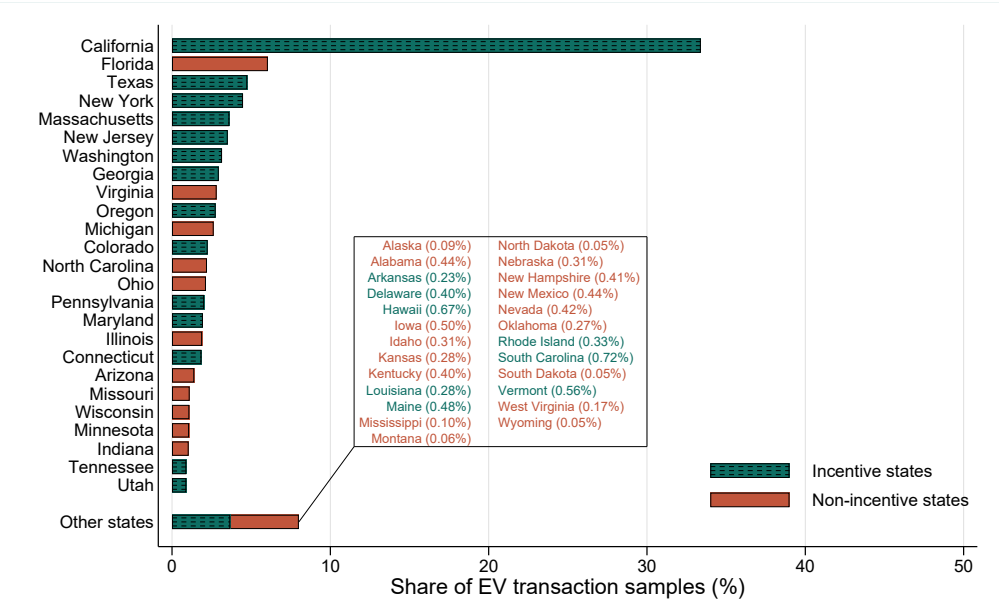
The programs differ along several of the dimensions that motivate our analysis. The geographic distribution of EV transactions is highly concentrated. Figure 4 shows each state's share of EV transactions before and after applying the survey weights. Panel (a) shows that California accounts for roughly one-third of EV observations in the unweighted NVCS sample, already far more than any other state. Panel (b) shows that this concentration becomes even more pronounced in the weighted sample. California accounts for nearly one-half of weighted EV transactions, while Florida remains a distant second and no other state accounts for a comparably large share. The difference between the two panels reflects the NVCS sampling design and underscores the importance of reweighting the survey to recover the geographic distribution of EV transactions in the U.S. market. At the same time, the remaining transactions span a broad set of incentive and non-incentive states, providing substantial cross-state variation in exposure to state EV incentive programs.

Figure 5 illustrates the cross-state variation in the type of incentive offered during our sample period. Among the 22 states with a qualifying program, rebates are the most common form, used by 14 states. Five states provide incentives through income tax credits, while three use exemptions or credits against sales, excise, or use taxes. The remaining states do not offer an EV incentive during our sample period. This variation in statutory form is closely related to how and when consumers receive the incentive, but the two dimensions are not identical.

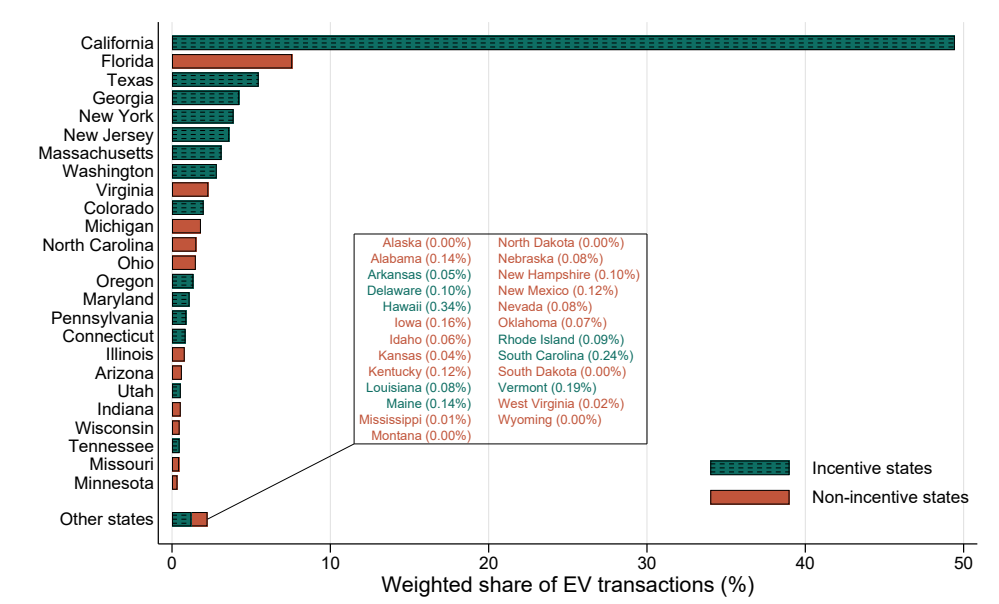
Figure 6 shows corresponding variation in when incentives are delivered. Post-transaction delivery is the most common approach, used by 12 of the 22 states with a qualifying program. Five states provide incentives at the point of transaction, while three allow buyers to choose between delivery methods. The remaining two states, Colorado and Oregon, change delivery method dur-

[10] As a robustness check, we also construct alternative incentive measures by assigning missing eligibility characteristics in the most favorable and least favorable ways possible. The resulting estimates are very similar to those from our baseline specification.

Figure 4: Distribution of EV transactions across states



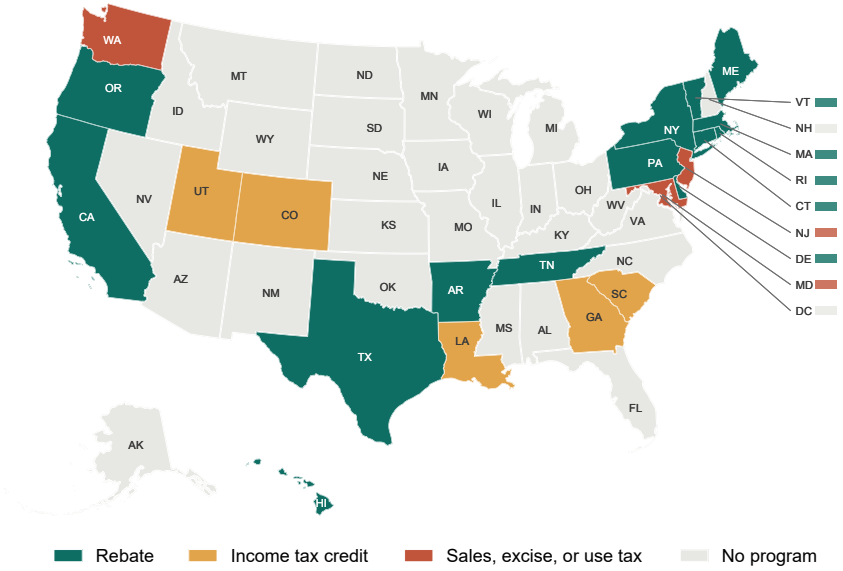
(a) Unweighted transactions



(b) Weighted transactions

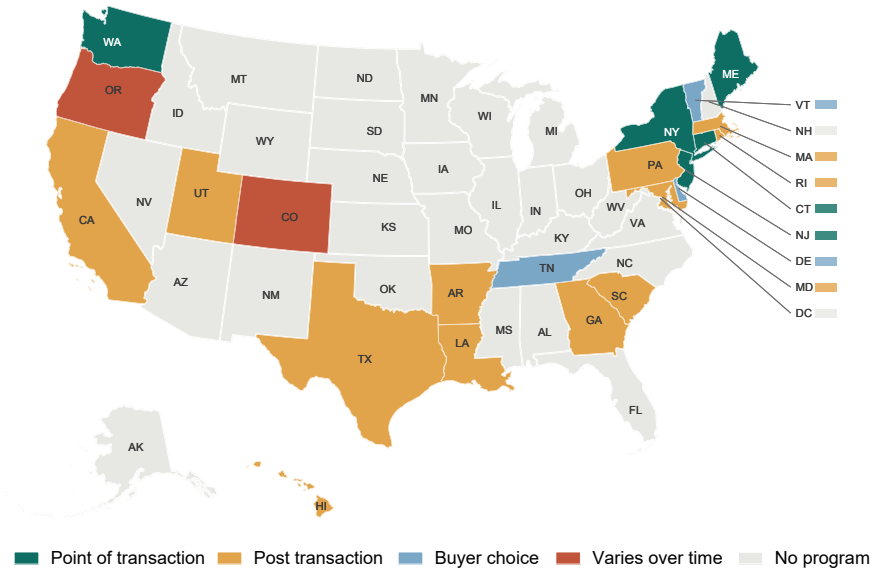
Notes: Panel (a) reports each state's share of EV observations in the NVCS sample. Panel (b) reports the corresponding shares after applying the survey weights described in the text. EVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Incentive states are states that offered a state EV incentive at some point during the sample period. States with smaller shares are grouped under "Other states."

Figure 5: Variation in EV incentive program type across states



Notes: This figure classifies states according to the type of state EV incentive offered during the sample period. Program types include rebates, income tax credits, and sales, excise, or use tax incentives. States without a qualifying state EV incentive during the sample period are classified as having no program.

Figure 6: Variation in EV incentive delivery method across states

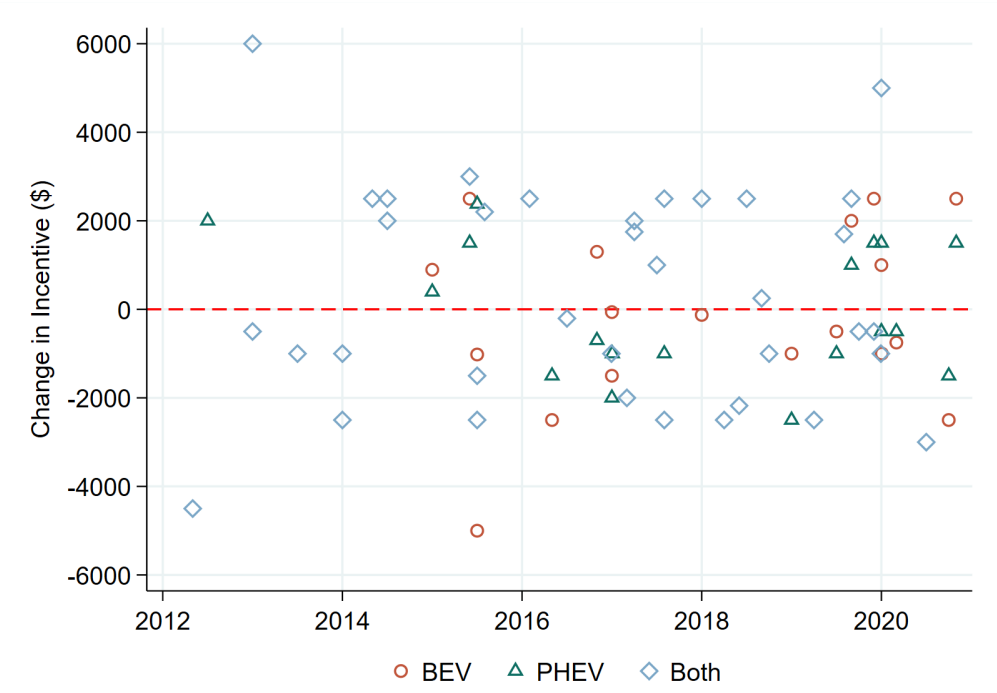


Notes: This figure classifies states according to the delivery method of state EV incentives during the sample period. Point-of-transaction incentives are applied as part of the vehicle transaction, post-transaction incentives are received after the transaction, and buyer-choice programs allow consumers to choose between delivery methods. Colorado and Oregon are classified as varying over time because their delivery methods changed during the sample period. States without a state EV incentive during the sample period are classified as having no program.

ing our sample period. This variation in delivery method is particularly relevant for our analysis because the timing of delivery may affect how strongly consumers incorporate the incentive into their purchase decision.

The cross-state differences documented above are accompanied by substantial changes in incentive generosity within states over time. Figure 7 plots changes in state incentive amounts during our sample period, distinguishing changes that apply to BEVs, PHEVs, or both. Both increases and decreases occur throughout the sample, with individual changes ranging from reductions of several thousand dollars to increases of as much as roughly $6,000. Programs also change the relative treatment of BEVs and PHEVs: some changes apply to both vehicle types, while others affect only one. State incentive policy therefore varies not only across states, but also substantially within states over time and across eligible vehicle types.

Figure 7: Changes in state EV incentive amounts over time



Notes: This figure reports changes in state EV incentive amounts during the sample period. Positive values indicate increases in the incentive amount and negative values indicate decreases. Changes are classified according to whether they apply to battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), or both vehicle types. The dashed horizontal line denotes no change in the incentive amount.

Eligibility for leases provides another important source of variation. Purchases are always eligible for the state incentives in our sample, conditional on satisfying the other program requirements, whereas leases are eligible only under some programs and may be subject to minimum lease length

requirements. Programs also differ in their treatment of buyer income. Some impose upper-income eligibility limits, while others provide additional incentives to lower-income buyers. Together, these features generate substantial variation in both the amount and design of the incentives facing otherwise similar vehicle transactions across states and over time.

Federal incentives operated alongside these state programs throughout our sample period. Under Section 30D of the Internal Revenue Code, qualifying new plug-in vehicles were eligible for a federal income tax credit of up to $7,500. The statutory credit depended on battery capacity: it consisted of a $2,500 base amount, an additional $417 for a vehicle with at least 5 kWh of battery capacity, and another $417 for each kWh above 5 kWh, up to the $7,500 maximum. Unlike many of the state programs, the federal credit during our sample period did not impose buyer-income or vehicle-MSRP limits, although it was nonrefundable and therefore could not exceed the purchaser's federal income tax liability. The credit was also subject to a manufacturer-specific phaseout once a manufacturer reached 200,000 qualifying vehicle sales. This phaseout affects Tesla and General Motors during our sample: Tesla's credit falls to 50 percent of the otherwise available amount in January 2019, to 25 percent in July 2019, and to zero in January 2020, while the corresponding reductions for General Motors begin in April 2019, October 2019, and April 2020. For leased vehicles, the credit accrues to the vehicle owner rather than directly to the lessee.

Using the vehicle-specific credit amounts published by the U.S. Internal Revenue Service (IRS; Internal Revenue Service, 2020), we determine the federal credit for which each transaction in our sample was eligible. In our baseline analysis, we include only state incentives in the incentive measure. As a robustness check, we separately control for either the dollar amount of the federal credit available at the time of the transaction or an indicator for federal credit eligibility.

3 Framework for Pass-Through and Program Design

This section sets out what determines the pass-through of an incentive to consumers and how program design may shift it, drawing on the incidence literature for taxes and subsidies. The setting is a market for a differentiated good in which sellers have market power.

3.1 Incidence under imperfect competition

Let S be the incentive available on a transaction, P the transacted price, and $P^c = P - S$ the price the consumer pays net of the incentive.[11] Define

$$\rho \equiv -\frac{dP^c}{dS} = 1 - \frac{dP}{dS}. \tag{1}$$

Full pass-through corresponds to $\rho = 1$. If $\rho > 1$, the consumer price falls by more than the incentive. The transacted price then falls as the incentive rises. We treat the seller side as a single decision maker. This abstracts from successive pricing along the supply chain. Incidence on consumers depends only on the total response of the consumer price.

Weyl and Fabinger (2013) show that under symmetric imperfect competition,

$$\rho = \frac{1}{1 + \dfrac{\theta}{\epsilon_\theta} + \dfrac{\epsilon_D - \theta}{\epsilon_S} + \dfrac{\theta}{\epsilon_{ms}}}, \tag{2}$$

where ϵ_D is the elasticity of market demand, ϵ_S the elasticity of the inverse marginal cost curve, ϵ_{ms} the elasticity of the inverse marginal surplus function, and $\epsilon_\theta \equiv \theta/[q(d\theta/dq)]$. The conduct parameter θ ranges from zero under perfect competition to one under monopoly, and we restrict θ to $(0, 1)$. Equation (2) is a local expression, that is, it gives ρ for an infinitesimal change in S, with θ and the elasticities evaluated at the prevailing price and quantity. It also conditions on the program design: conduct is assumed to respond to the incentive only through quantity, not directly.

We assume sellers price uniformly within segments and treat demand and pricing across segments as locally separable. Segments are defined by the consumer, product, and transaction characteristics relevant to pricing at the transaction. Equation (2) then applies segment by segment, with segment-specific primitives.[12] Then, pass-through is the quantity-weighted average of segment pass-through rates.

Under perfect competition with constant marginal cost, $\theta = 0$ and ϵ_S is infinite, so $\rho = 1$ and the consumer captures the incentive exactly. Three channels move pass-through away from one. The first is the slope of marginal cost: under the usual case of positive and increasing marginal cost, a finite ϵ_S lowers pass-through, as rising marginal cost absorbs part of the demand increase. The

[11] P is the price the seller receives, gross of the incentive. In our setting the seller is the dealer, and our transaction data record this price. Equivalently, $P^c = P + t$ with $t = -S$ a negative tax (Weyl and Fabinger, 2013).

[12] This parallels the treatment of markets separated by third-degree price discrimination in Weyl and Fabinger (2013).

second is demand curvature: with marginal cost constant and conduct invariant to quantity, $\rho > 1$ if and only if demand is log-convex. The third is the response of conduct: under price competition with discrete-choice demand, markets are typically less competitive at higher prices, so $\epsilon_\theta < 0$ and pass-through is higher. The last two channels require market power (i.e., $\theta > 0$).

Equation (1) provides the link to our empirical analysis: dP/dS is the response of the transacted price to the incentive. Because observed changes in the incentive are discrete, the empirical counterpart is a finite-change analogue of dP/dS, averaging local price responses over the relevant range rather than identifying ρ at a single equilibrium.

3.2 Delivery of the incentive

Programs vary in the timing of incentive delivery. Under point-of-transaction delivery the incentive is applied at the transaction, so the buyer pays $P^c = P - S$. Under post-transaction delivery the buyer pays P at the transaction and claims the incentive afterward.

Within the framework of Section 3.1, whether the incentive is paid to the seller or directly to the buyer at the time of the transaction has the same effect on the equilibrium price (Weyl and Fabinger, 2013), provided consumers fully incorporate the incentive into their purchase decision. Delivery can matter, however, if it affects the weight consumers place on the incentive when making that decision. Chetty et al. (2009) make the analogous point for taxes: statutory incidence can affect economic incidence when it determines whether an amount is incorporated into the price consumers observe and therefore how salient it is at the time of choice.

We capture this margin with a salience parameter $\sigma \in [0, 1]$, which denotes the weight the buyer places on the incentive when making the transaction. We take point-of-transaction delivery as the benchmark, with $\sigma = 1$. Post-transaction delivery admits $\sigma < 1$, because an incentive claimed only after the transaction may be less salient at the time the buyer chooses the vehicle.[13] We abstract from incomplete take-up and costs of claiming the incentive, so that the buyer ultimately receives the full statutory amount.

We assume that the perceived incentive shifts consumer valuations in parallel, so that demand is $D(P - \sigma S)$.[14] The parameter σ is the counterpart of the attention parameter in Chetty et al. (2009), whose margin is the visibility of the sales tax and posted price rather than the timing of receipt. We treat σ as locally invariant to the size of the incentive and abstract from direct effects

[13] Section 3.1 maintains $\sigma = 1$.

[14] We also assume attention is homogeneous within a segment. Otherwise the shift in aggregate demand is not parallel, and (3) holds up to a term proportional to θ.

of delivery on sellers' costs, conduct, and product offerings. Delivery therefore affects equilibrium only through the weight consumers place on the incentive when making their purchase decisions.

The equilibrium then depends on S only through σS. A unit parallel upward shift in consumer valuations raises the transacted price by $1-\rho$.[15] Here, ρ denotes the full-salience pass-through rate associated with the relevant demand and market structure. It follows that a shift of σS changes the transacted price according to

$$\frac{dP}{dS} = \sigma\,(1-\rho), \tag{3}$$

with ρ as in equation (2). The regression coefficient therefore recovers $\sigma(1-\rho)$ rather than $1-\rho$, and σ is not separately identified from ρ. Since the buyer ultimately receives the full statutory incentive, the price the buyer pays net of the incentive is $P-S$. Consumer pass-through is therefore

$$\rho_c \;\equiv\; -\frac{d\,(P-S)}{dS} \;=\; 1-\sigma\,(1-\rho). \tag{4}$$

Under point-of-transaction delivery, $\sigma = 1$, so equation (4) reduces to equation (1) and $\rho_c = \rho$. Pass-through therefore coincides with the rate implied by the underlying demand and market structure, preserving any incomplete pass-through or over-shifting generated by those market conditions.

Under post-transaction delivery, by contrast, $\sigma < 1$, so consumers place less weight on the incentive when making their purchase decision. The resulting demand response is weaker, which attenuates the equilibrium price response. Relative to the full-salience benchmark, $\rho_c - \rho = (1-\sigma)(1-\rho)$. Post-transaction delivery therefore moves consumer pass-through toward one from either direction, raising it when $\rho < 1$ and lowering it when $\rho > 1$.

Equivalently, equation (4) can be written as $\rho_c - 1 = \sigma(\rho - 1)$. The salience parameter therefore scales the deviation of consumer pass-through from one, summarizing how less salient delivery attenuates the price response implied by the underlying market.

3.3 Purchases and leases

Pass-through may also depend on whether the vehicle is purchased or leased. We treat purchases and leases as separate segments within the framework of Section 3.1. Because they represent different contractual arrangements, the two transaction types may differ in demand elasticity and

[15] Weyl and Fabinger (2013) state this for perfect competition and for monopoly. The same argument applies under symmetric imperfect competition, because a constant added to inverse demand leaves marginal surplus unchanged and the shift is therefore equivalent to a uniform reduction in marginal cost.

curvature, the slope of marginal cost, or conduct. Equation (2) therefore allows pass-through to differ between purchases and leases, without implying which transaction type should have higher pass-through or whether pass-through should be below or above one.

3.4 Consumer income

Consumer characteristics can also generate heterogeneity in pass-through. In particular, consumers at different income levels may face distinct demand and pricing environments, including differences in demand elasticity or curvature and in conduct. The framework in Section 3.1 therefore allows pass-through to vary across income segments without implying a monotonic relationship with income: different income segments may exhibit incomplete, full, or greater-than-full pass-through.

4 Empirical Strategy

We estimate the parameter $\mathrm{d}P/\mathrm{d}S$ by regressing transaction prices on incentive amounts. Equation (5) presents our main specification

$$P_i = \beta_0 + \beta_1 S_i + \nu_{l(i)} + \delta_{ym(i)} + \eta_{v(i)} + \varepsilon_i, \tag{5}$$

where P_i is the price of transaction i and S_i is the state-level incentive for which transaction i was eligible. Our data allow us to observe the state, $l(i)$, in which transaction i occurred, the year-month, $ym(i)$, during which the transaction occurred, and the vehicle, $v(i)$, associated with the transaction.[16]

We include the term $\eta_{v(i)}$, which denotes a set of vehicle fixed effects, to control for vehicle-specific price effects that are time invariant. The term $\nu_{l(i)}$ denotes state fixed effects, which control for unobserved, time-invariant price differences across states. The term $\delta_{ym(i)}$ denotes year-by-month fixed effects, which control for period-specific shocks to prices that are common across all vehicles and all states. The idiosyncratic error term, ε_i, is two-way clustered by vehicle $v(i)$ and state $l(i)$ allowing for correlation across transactions involving the same vehicle $v(i)$ or occurring in the same state $l(i)$. Observations are weighted to match the Consumer Expenditure Survey income distribution and Experian vehicle registration counts.

Our identifying assumption is that, conditional on the vehicle, state, and year-month fixed effects, variation in state incentive amounts is uncorrelated with other unobserved determinants of transaction prices. We therefore interpret β_1 as the empirical counterpart of $\mathrm{d}P/\mathrm{d}S$, measuring the

[16] We define vehicles as vehicle identification number (VIN) by fuel-type combinations.

average change in the transacted price associated with a one-dollar increase in the state incentive. Because the consumer receives the incentive in addition to any resulting change in the transacted price, the implied pass-through rate is given by $\rho_c = 1-\beta_1$. Full pass-through therefore corresponds to $\beta_1 = 0$, while $\beta_1 < 0$ implies over-shifting and $\beta_1 > 0$ implies incomplete pass-through.

We examine heterogeneity in pass-through along the three dimensions considered in Section 3: across incentive delivery methods, between purchases and leases, and across buyer income groups. For this purpose, we estimate Equation (5) separately for each group g:

$$P_i = \beta_{0g} + \beta_{1g} S_i + \nu_{l(i),g} + \delta_{ym(i),g} + \eta_{v(i),g} + \varepsilon_i, \qquad i \in g. \tag{6}$$

The implied pass-through rate for group g is $\rho_{c,g} = 1 - \beta_{1g}$.[17]

To test whether pass-through differs statistically across groups, we additionally estimate a pooled version of Equation (5) in which the incentive slope is allowed to vary across groups. Specifically, we include group indicators and interactions between the incentive amount and the group indicators, while retaining the same vehicle, state, and year-month fixed effects:

$$\begin{aligned} P_i = \beta_0 + \sum_{g=2}^{G} \gamma_g \mathbb{1}(G_i = g) + \sum_{g=1}^{G} \beta_g S_i \mathbb{1}(G_i = g) \\ + \nu_{l(i)} + \delta_{ym(i)} + \eta_{v(i)} + \varepsilon_i. \end{aligned} \tag{7}$$

Here, G_i denotes the group to which transaction i belongs and β_g is the incentive slope for group g. Since pass-through for group g is $1 - \beta_g$, equality of pass-through across groups is equivalent to equality of these slopes. We test equality of the purchase and lease slopes and jointly test equality across the five income-group slopes. For incentive delivery method, we jointly test equality across the three delivery-method slopes and also conduct pairwise tests comparing buyer choice, point-of-transaction delivery, and post-transaction delivery.

As a robustness check, we also account explicitly for federal EV incentives. Our baseline incentive variable S_i includes state-level incentives only. We augment the preferred specification in two ways. First, we control for the dollar amount of the federal incentive for which a transaction was eligible. Second, we control for an indicator for federal incentive eligibility. In both cases, the state

[17] For the delivery-method analysis, transactions that are not eligible for a state incentive do not have a delivery method and are included in each delivery-method regression as a common comparison group. The estimation samples for the three delivery methods therefore overlap.

incentive remains the variable of interest. We repeat the aggregate and heterogeneity specifications using the same weights, fixed effects, and two-way clustering.

We further assess the sensitivity of statistical inference to alternative procedures. In addition to our preferred two-way clustering by vehicle and state, we consider clustering by state, two-way clustering by vehicle and state-model-year, and a wild cluster bootstrap at the state level.

5 Results

We first present our estimates of average pass-through, and then examine heterogeneity across incentive delivery methods, between purchases and leases, and across buyer income groups. We conclude with robustness checks that explicitly account for federal EV incentives and assess the sensitivity of our inference to alternative clustering procedures

5.1 Average pass-through

Table 2 presents our estimates of the average pass-through of state-level EV incentives. Column (1) includes vehicle fixed effects, Column (2) adds state fixed effects, and Column (3) further adds year-month fixed effects.

Table 2: Subsidy Pass-Through to Consumer Prices

	(1)	(2)	(3)
Subsidy ($)	-0.002	0.009	0.008
	(0.091)	(0.090)	(0.087)
VIN fixed effects	Yes	Yes	Yes
State fixed effects	No	Yes	Yes
Year-month fixed effects	No	No	Yes
N	1,033,280	1,033,280	1,033,280
Implied pass-through	100.2%	99.1%	99.2%

Notes: This table reports coefficient estimates and standard errors from three least squares regressions using transaction-level observations of new vehicle purchases and leases from 2012 to 2020. The dependent variable is the transacted price of the vehicle in dollars. The implied pass-through rate is one minus the reported coefficient. Observations are weighted to match Consumer Expenditure Survey income distributions and Experian registration counts. Standard errors are clustered at the state and vehicle (VIN) levels. *** Significant at the 1% level, ** at the 5% level, * at the 10% level, for a test of the null hypothesis that the coefficient equals zero, which corresponds to full pass-through.

Across the three specifications, the estimated pass-through rate is essentially unchanged and close to 100 percent. We take Column (3), which includes vehicle, state, and year-month fixed effects, as our preferred specification.

The estimated coefficient on the incentive amount is 0.008, implying a pass-through rate of 99.2 percent. The coefficient is economically small and statistically indistinguishable from zero, so we cannot reject full pass-through. In dollar terms, a $1,000 increase in the state incentive raises the transacted price by only about $8, so the price paid by the consumer net of the incentive falls by approximately $992. Our preferred estimate therefore implies that consumers capture essentially the full value of state EV incentives, on average.

5.2 Heterogeneity in pass-through

The near-full pass-through rate estimated for the market as a whole may conceal substantial heterogeneity across policy design margins and buyer characteristics. We first examine two margins of program design—how the incentive is delivered and whether it applies to purchases or leases—and then turn to whether the incidence of an incentive dollar varies with buyer income.

Incentive delivery method. Table 3 reports estimates by incentive delivery method. We distinguish state programs that allow buyers to choose how the incentive is delivered, programs that apply the incentive at the point of transaction, such as through a sales-tax exemption or a rebate deducted directly from the purchase price, and programs in which the buyer receives the incentive after the transaction, such as through a rebate claimed after the purchase or a credit claimed on a subsequent tax return. Table 3 compares pass-through rates across the three delivery methods.

Table 3: Subsidy Pass-Through to Consumer Prices, By Delivery Method

	Buyer choice	Point of transaction	Post transaction
Subsidy ($)	0.077**	-0.266***	0.094
	(0.035)	(0.068)	(0.078)
VIN fixed effects	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes
N	686,602	723,444	894,663
Implied pass-through	92.3%	126.6%	90.6%

Notes: Similar to Table 2, this table reports coefficient estimates and standard errors from three separate least squares regressions, estimated separately by incentive delivery method. *** Significant at the 1% level, ** at the 5% level, * at the 10% level, for a test of the null hypothesis that the coefficient equals zero, which corresponds to full pass-through.

The differences across delivery methods are substantial. We estimate a pass-through of 126.6 percent when the incentive is applied at the point of transaction, compared with 92.3 percent when

the buyers can choose the delivery method and 90.6 percent when the incentive is received after the transaction. We reject full pass-through for point-of-transaction incentives in favor of over-shifting and for buyer-choice incentives in favor of incomplete pass-through, while the post-transaction estimate is statistically indistinguishable from full pass-through.

These differences are also statistically significant across delivery method. We reject the joint null that the three incentive slopes are equal ($p = 0.001$). Point-of-transaction delivery differs significantly from both buyer choice and post-transaction delivery ($p < 0.001$ in each case), whereas we cannot reject equality between buyer choice and post-transaction delivery ($p = 0.108$).

The distinction between point-of-transaction and post-transaction delivery is consistent with the salience mechanism discussed in Section 3. Point-of-transaction delivery is the full-salience benchmark in the model, so the estimated pass-through rate reflects the price response generated by the underlying demand and market structure. When the incentive is received only after the transaction, lower salience attenuates this price response and moves consumer pass-through toward 100 percent. Consistent with this prediction, pass-through is much farther from 100 percent under point-of-transaction delivery than under post-transaction delivery.

Purchases and leases. The second policy design margin we study is whether incentive pass-through differs between purchases and leases. Purchases are always eligible for the state incentives in our sample, whereas leases are eligible only under some programs. When leases are eligible, the same statutory incentive need not translate into the same price reduction for lessees as for buyers because purchases and leases constitute distinct market segments with potentially different demand and supply conditions. Table 4 shows the estimates obtained separately for purchases and leases.

We find sharply different pass-through rates for purchases and leases. For purchases, the estimate implies a pass-through of 117.5 percent, and we reject full pass-through in favor of over-shifting. By contrast, for leases, pass-through is substantially lower at 60.2 percent, and we reject full pass-through in favor of incomplete pass-through. The difference between the purchase and lease slopes is statistically significant ($p = 0.034$).

The magnitude of this difference is economically important. A \$1,000 increase in the incentive lowers the consumer's price net of the incentive by approximately \$1,175 for a purchase but only about \$602 for a lease. Thus, the approximately full pass-through we estimate in the aggregate masks incidence on opposite sides of 100 percent across vehicle purchases and leases.

The pass-through framework in Section 3 does not impose a ranking between purchases and

Table 4: Subsidy Pass-Through to Consumer Prices, By Financing Method

	Purchases	Leases
Subsidy ($)	-0.175**	0.398***
	(0.067)	(0.078)
VIN fixed effects	Yes	Yes
State fixed effects	Yes	Yes
Year-month fixed effects	Yes	Yes
N	823,881	207,046
Implied pass-through	117.5%	60.2%

Notes: Similar to Table 2, this table reports coefficient estimates and standard errors from two separate least squares regressions, estimated separately for vehicle purchases and leases. *** Significant at the 1% level, ** at the 5% level, * at the 10% level, for a test of the null hypothesis that the coefficient equals zero, which corresponds to full pass-through.

leases. The two segments may differ in demand elasticity and curvature, the slope of marginal cost, or conduct, any of which can generate different pass-through rates. Our estimates highlight that these differences can be large enough in practice to produce over-shifting for purchases and substantial incomplete pass-through for leases. Importantly, this distinction matters for policy design. Extending eligibility to leases broadens the reach of an incentive program, but equal eligibility does not necessarily imply equal effects. Each incentive dollar lowers the consumer's net price substantially more when it applies to a purchase than when it applies to a lease.

Buyer income. Finally, we examine whether the incidence of an incentive dollar varies with buyer income. Concerns about the distributional consequences of EV incentives have largely focused on which households receive them, since EV buyers tend to have higher incomes. We ask a different but also important question: whether the marginal incentive dollar is passed through differently across income groups. Table 5 reports the results for five income groups.

Pass-through varies significantly across income groups, but the relationship is not monotonic. Pass-through is 129.8 percent for buyers with household income of $45,000 or less, declines through the middle of the income distribution and reaches 71.8 percent for buyers with income between $85,000 and $125,000, before returning to approximately 100 percent for the two highest-income groups. We reject full pass-through for the lowest-income and $85,000–$125,000 income groups, but not for the other three groups. We also strongly reject equality of the five income-group slopes ($p < 0.001$).

Table 5: Subsidy Pass-Through to Consumer Prices, By Income Group

	$\leq$ \$45k	\$45–85k	\$85–125k	\$125–200k	$>$ \$200k
Subsidy (\$)	-0.298**	0.052	0.282**	0.001	-0.034
	(0.132)	(0.123)	(0.130)	(0.094)	(0.155)
VIN fixed effects	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
N	123,651	278,600	244,100	219,813	153,230
Implied pass-through	129.8%	94.8%	71.8%	99.9%	103.4%

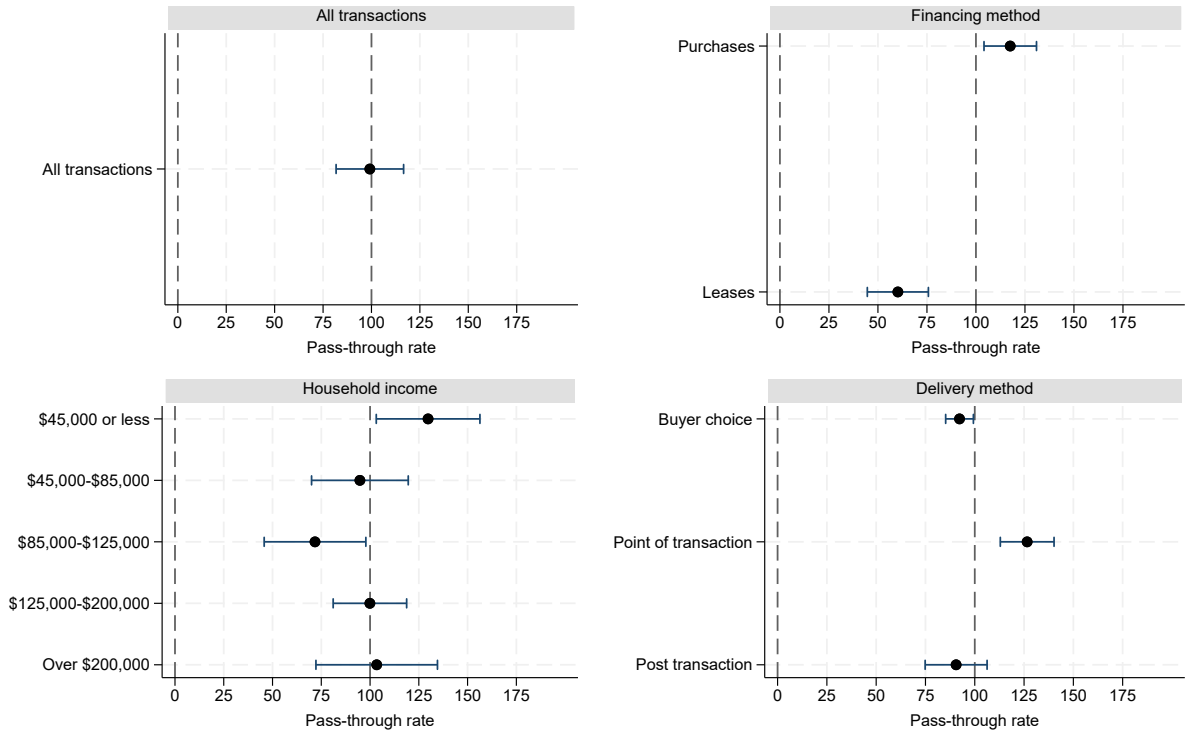
Notes: Similar to Table 2, this table reports coefficient estimates and standard errors from five separate least squares regressions, estimated separately by buyer income group. *** Significant at the 1% level, ** at the 5% level, * at the 10% level, for a test of the null hypothesis that the coefficient equals zero, which corresponds to full pass-through.

This non-monotonic pattern is consistent with the pass-through framework presented in Section 3, which allows income groups to face different demand and pricing environments and therefore does not necessarily imply a monotonic relationship between income and pass-through. In particular, the estimates provide no evidence that the marginal incentive dollar is passed through more strongly as buyer income rises. The highest pass-through estimate is for the lowest-income group, while pass-through among the two highest-income groups is approximately full.

This result distinguishes the incidence of the marginal incentive dollar from the distribution of total program spending. EV incentives may disproportionately accrue to higher-income households because those households are more likely to purchase eligible vehicles, but conditional on a transaction taking place, we do not find a corresponding tendency for higher-income buyers to capture a larger share of an additional incentive dollar.

More broadly, Figure 8 summarizes the estimates from Tables 2 through 5 and illustrates how the near-full pass-through we estimate on average obscures economically important differences across policy design margins and buyer characteristics. Although average pass-through is close to 100 percent, the estimates vary substantially with how incentives are delivered, between purchases and leases, and across buyer income groups, ranging from incomplete pass-through to over-shifting.

Figure 8: Subsidy Pass-Through to Consumer Prices



5.3 Robustness Checks

We conduct two sets of robustness checks. First, our baseline incentive measure includes state-level incentives only, while federal EV incentives were also available during the sample period. We therefore re-estimate the aggregate and heterogeneity specifications while controlling either for the dollar amount of the federal incentive for which each transaction was eligible or for an indicator for federal incentive eligibility.

Accounting explicitly for federal incentives has little effect on our findings. Appendix Figures A.2 and A.3 report the corresponding estimates. Aggregate pass-through is 97.2 percent when we control for the federal incentive amount and 99.3 percent when we instead control for federal eligibility, compared with 99.2 percent in the preferred specification. The purchase and lease estimates are similarly stable: pass-through is 115.1 and 59.6 percent, respectively, when we control for federal incentive amount, and 117.9 and 60.2 percent when we control for federal eligibility. The estimates for the remaining dimensions of heterogeneity are similarly robust. Point-of-transaction pass-through remains about 126–127 percent and substantially above the estimates for the other delivery methods, while the non-monotonic relationship between buyer income and pass-through

is preserved. Explicitly accounting for federal incentives therefore does not materially affect either the aggregate pass-through estimate or the main heterogeneity patterns.

Second, we assess the robustness of our conclusions to alternative standard-error and bootstrap procedures. Our preferred standard errors are two-way clustered by vehicle and state. We compare these with standard errors clustered by state, two-way clustering by vehicle and state-model-year, and a wild cluster bootstrap at the state level. Appendix Figures A.4–A.7 report the corresponding point estimates and confidence intervals for the aggregate estimate and each of the heterogeneity analyses under all four approaches. Because these exercises change how uncertainty is estimated rather than the estimating equation, the point estimates are unchanged. The width of confidence intervals varies across approaches, but the substantive patterns in the estimates remain the same.

6 Conclusion

EV incentives are typically described by their statutory generosity, but the amount offered by the government need not equal the benefit ultimately received by the consumer. In this paper, we use transaction-level data on new vehicle purchases and leases together with a comprehensive database of U.S. state EV incentive programs to estimate the pass-through of these incentives and how it varies with program design and buyer characteristics. Our preferred estimate implies an average pass-through rate of approximately 100 percent, so consumers capture essentially the full value of state EV incentives on average. This aggregate estimate, however, masks substantial heterogeneity. Pass-through is substantially higher for incentives delivered at the point of transaction than for those received after the transaction, and differs sharply between purchases and leases, with over-shifting for purchases but incomplete pass-through for leases. Pass-through also varies significantly across income groups, following a non-monotonic pattern rather than increasing with buyer income. These findings are robust to explicitly accounting for federal EV incentives and to alternative approaches to statistical inference.

The results have direct implications for incentive design. Statutory generosity and economic incidence are distinct: two programs offering the same dollar incentive can generate substantially different benefits for consumers depending on how the incentive is delivered and which transactions qualify. In our setting, point-of-transaction incentives generate substantially greater pass-through than post-transaction incentives. Similarly, extending an incentive to leases broadens the set of eligible transactions, but our estimates imply that each incentive dollar produces a considerably smaller reduction in the consumer's price for a lease than for a purchase. The distributional implications

also extend beyond deciding which income groups are eligible. Although higher-income households receive a disproportionate share of EV incentives because they are more likely to purchase EVs, we find no corresponding tendency for the marginal incentive dollar to be passed through more strongly to higher-income buyers. Evaluating incentive programs therefore requires considering not only who qualifies and how much the government spends, but also how program design affects the incidence of that spending.

These policy lessons have become particularly timely. Federal clean-vehicle tax credits are no longer available for vehicles acquired after September 30, 2025, increasing the role of state incentives in supporting EV adoption. States have already begun responding to this change in federal policy. Colorado increased the rebates available through its income-qualified Vehicle Exchange Colorado program in November 2025, while California launched MyFirstEV in August 2026, which provides point-of-sale incentives to first-time buyers and lessees of zero-emission vehicles.[18] As states introduce, expand, and redesign their own programs, choices about delivery method, eligibility, and the treatment of purchases and leases will become increasingly consequential. Our results show that the effectiveness and distributional consequences of these programs depend not only on the number of incentive dollars offered, but also on how those dollars are delivered to the market.

[18]Sources: Colorado Energy Office, Vehicle Exchange Colorado, `https://coloradoenergyoffice.powerappsportals.com/faq/`; California Climate Investments, MyFirstEV, `https://www.caclimateinvestments.ca.gov/myfirstev`.

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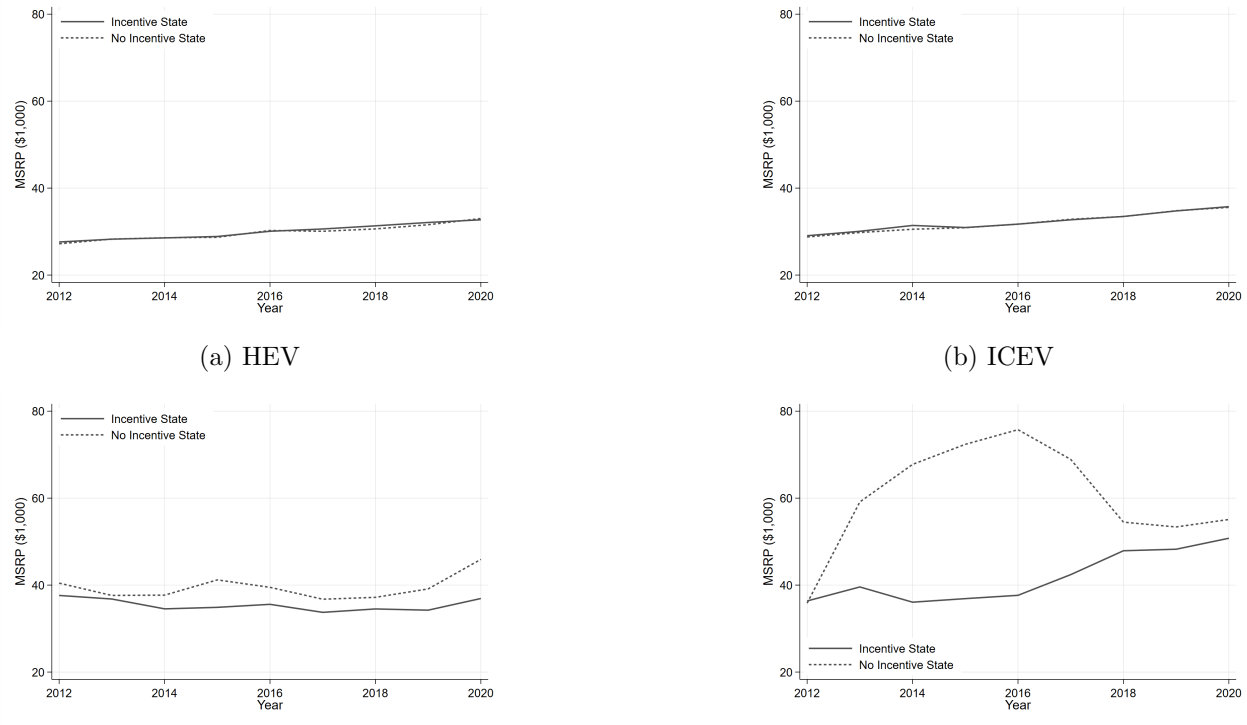
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A Additional Figures and Tables

Appendix Figure A.1: Average vehicle MSRP by fuel type and incentive-state status.



(a) HEV

(b) ICEV

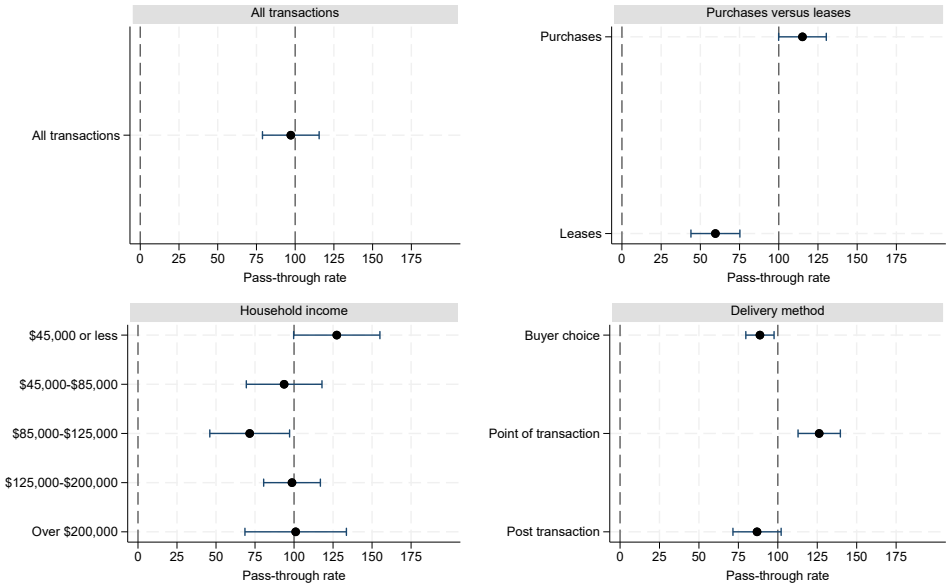
(c) PHEV

(d) BEV

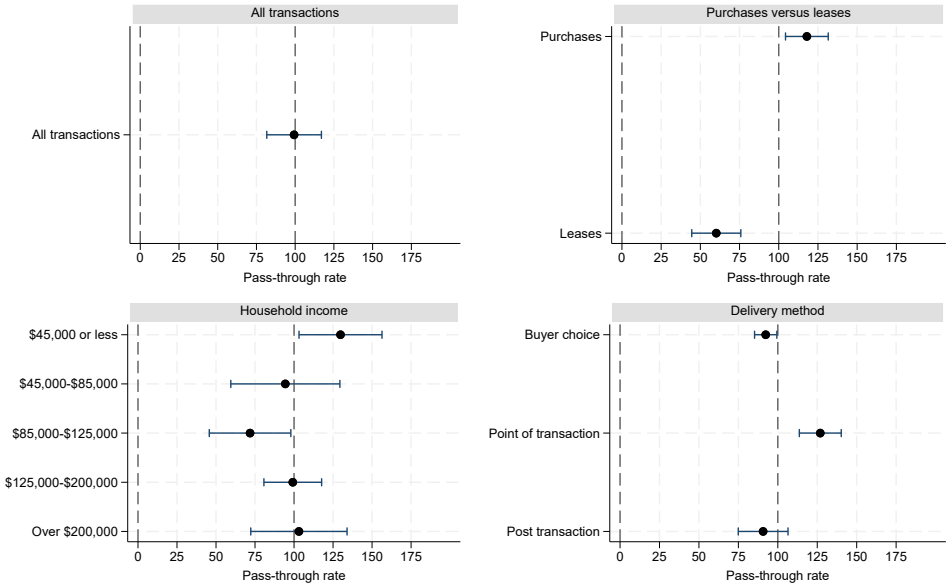
Notes: This figure reports annual average manufacturer suggested retail prices (MSRP) separately for internal combustion engine vehicles (ICEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs). A state is classified as an incentive state if it offered a qualifying state vehicle incentive at any point during the sample period. Averages are weighted using the survey weights described in the text. MSRP averages are calculated among transactions with non-missing MSRP.

Appendix

Appendix Figure A.2: Subsidy Pass-Through to Consumer Prices, Controlling for Federal Incentive Amount

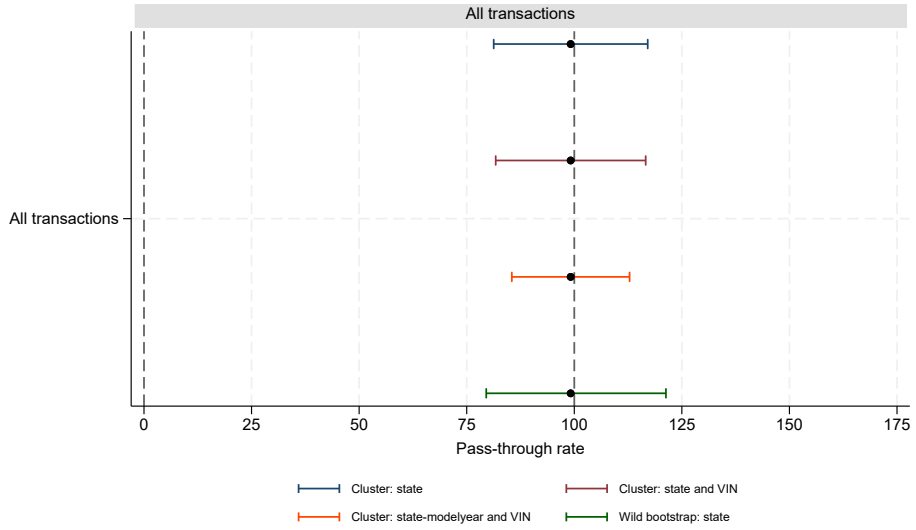


Appendix Figure A.3: Subsidy Pass-Through to Consumer Prices, Controlling for a Federal Incentive Indicator

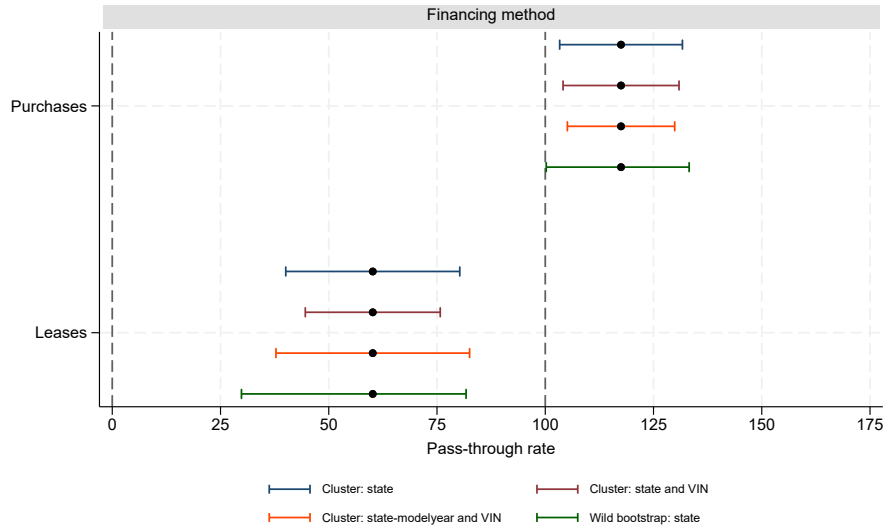


Appendix

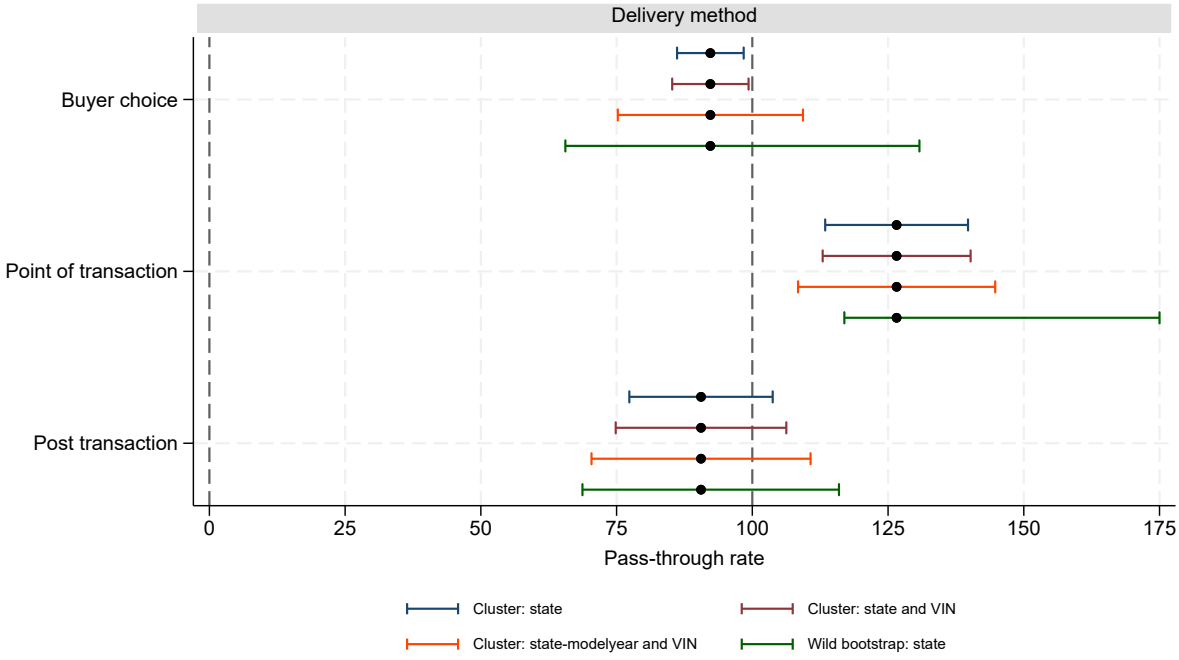
Appendix Figure A.4: Alternative Inference Procedures: All Transactions



Appendix Figure A.5: Alternative Inference Procedures, Purchases versus Leases



Appendix Figure A.6: Alternative Inference Procedures by Delivery Method



Appendix Figure A.7: Alternative Inference Procedures by Household Income

