FEDERAL RESERVE BANK of ATLANTA

Growing Electric Vehicle Adoption in the U.S.:

Implications of Different Funding Policies for Infrastructure Maintenance and Tax Burden on Families

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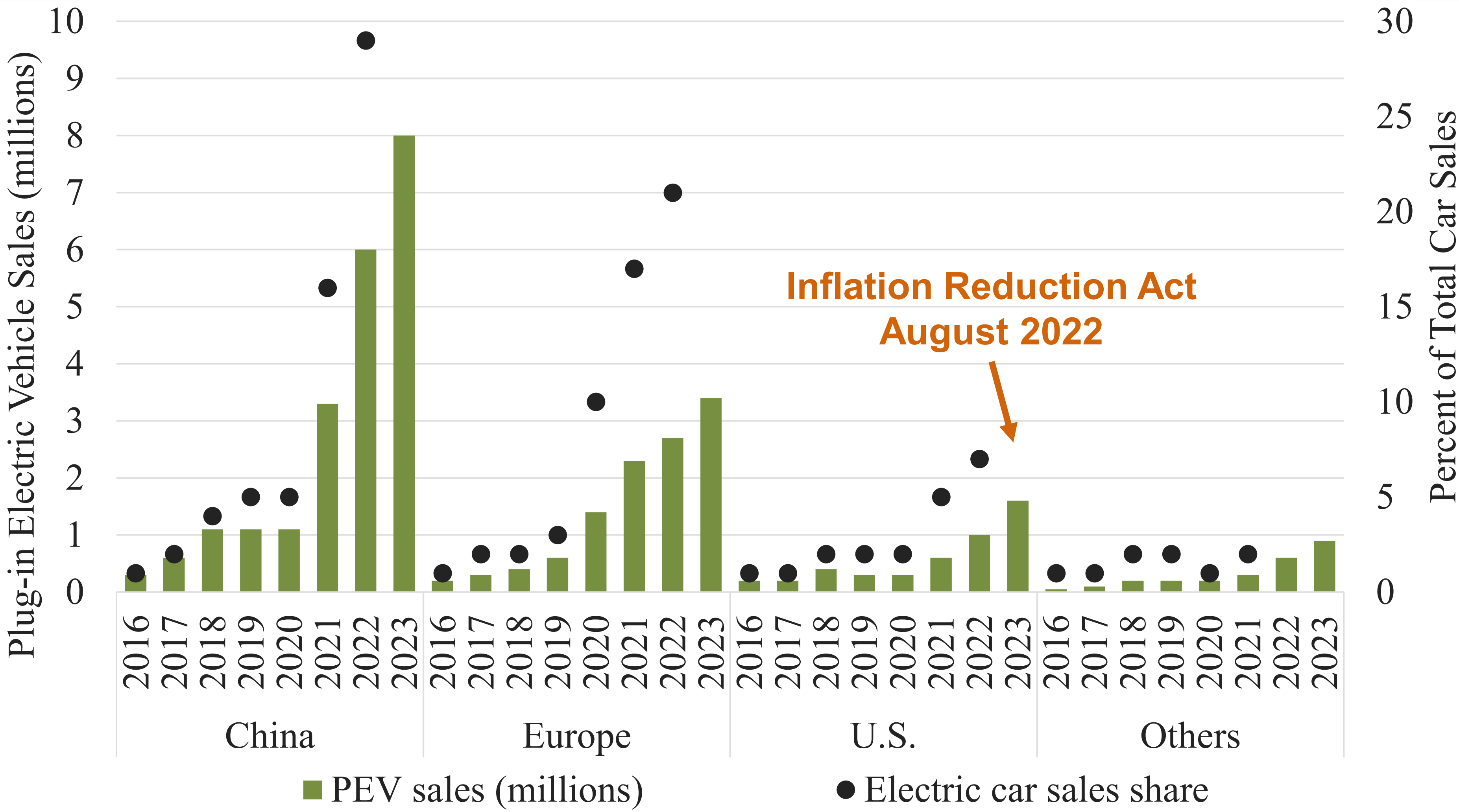
Plug-in Electric Vehicles (PEV)

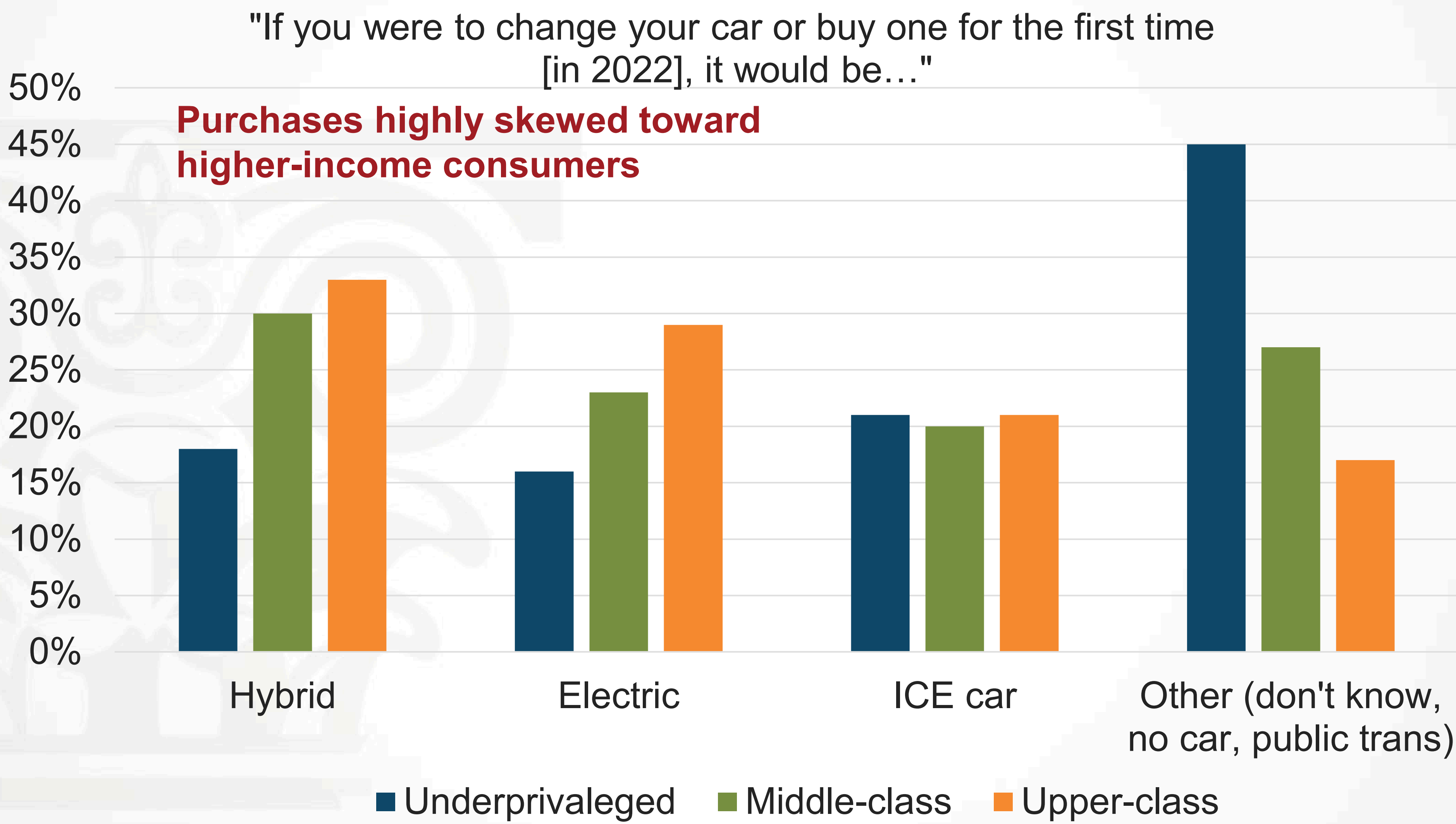
- Any road vehicle that uses an external source of **electricity** to recharge on-board batteries that are used to power an electric motor
  - **all-electricity/battery electric vehicles** (BEV)
    - e.g., Tesla (2008), Mitsubishi i-MiEV (2009), Nissan Leaf (2010)
  - **plug-in hybrid electric vehicles** (PHEV)
    - e.g., Toyota Prius (1997, 2000), Chevy Volt (2010)
- All major auto makers are making aggressive moves toward replacing ICE cars with PEVs
- Many states are placing restrictions on ICE cars
  - no sales of gas-powered cars in CA after 2035
  - all 2030 & later model cars in WA must be electric

Growing, but still small share of sales



Source: International Energy Agency (IEA), with authors' calculations.

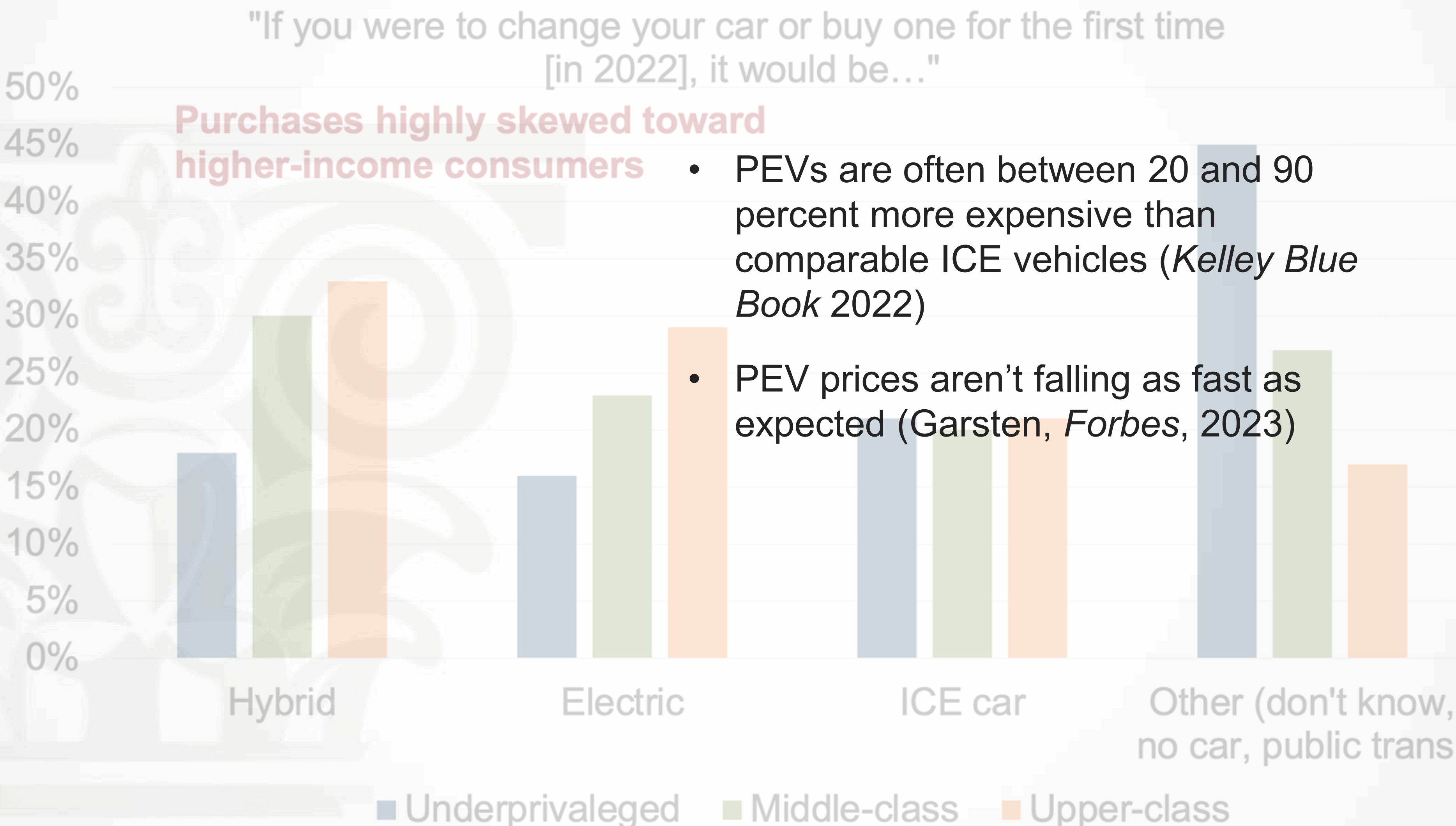
Electric Vehicles Still Out of Reach of Many



Source: Statista, https://www.statista.com/statistics/1296900/us-car-purchasing-intention-by-vehicle-type-and-household-income/

Electric Vehicles Still Out of Reach of Many

- PEVs are often between 20 and 90 percent more expensive than comparable ICE vehicles (*Kelley Blue Book* 2022)
- PEV prices aren’t falling as fast as expected (Garsten, *Forbes*, 2023)



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Implications of Growth in Electric Vehicles

- Less consumption of gasoline
- Declining revenues for road maintenance
  - 41% of spending on roads comes from gasoline and license taxes
- Incidence of gasoline tax falling increasingly on lower-income households

Research Questions

- What's the implication of growing PEV consumption on the **regressivity** of the gasoline tax?

- How can an **alternative** to the gasoline tax be structured to be less regressive?

Setting the Stage

- Federal gasoline tax = $0.184/gallon
  - unchanged since 1993
- Generates roughly $22 billion in revenue
  - revenues dedicated to Hwy Trust Fund starting 1956
- Preferred on efficiency grounds to other policy
  - e.g., mandated fuel standards for environmental policy
- Highly regressive
  - i.e., poor HHs pay a higher share of income on gasoline
- Insufficient to fund on-going road maintenance
  - HTF projected to face a $140 billion deficit by 2031

Summary of Analysis

- Estimate elasticities of demand for gasoline
  - by household income quartile
  - follow empirical strategy of West & Williams (2004, 2007)
- Simulate distributional implications of raising the tax
  - by enough to offset infrastructure externalities
  - change in ***consumer welfare*** (value of transaction)
- Compare with impact from lump sum policy alternative
  - structure policy to raise the same revenue as higher gas tax
  - consider 3 alternatives for assessment

Estimating Demand Elasticities

- Share Equations from Almost Ideal Demand System
  - Deaton & Muellbauer (1980), West & Williams (2004, 2007)

$$s_{ih} = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_i [\ln(y_h) - \ln a(\boldsymbol{p})] + \lambda_i \left\{ \frac{[\ln(y_h) - \ln a(\boldsymbol{p})]^2}{b(\boldsymbol{p})} \right\} + \sum_k \eta_{ik} Z_{hk} + u_{hi}$$

s_{ih}: household *h*'s expenditure share on good *i* with prices *p*

y_h: household real income

$\boldsymbol{p}$: prices (including wages)

Z_{hk}: taste shifters
- education
- race
- # children
- non-labor income
- propensity to consume gasoline
- state & year F.E.

Estimating Demand Elasticities & Incidence

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  - Estimated using _quaidsce_ command in Stata
    - 3 goods: gasoline, leisure, "other" (includes consumption of electricity)
- Tax Incidence Estimated by *Δ* in Consumer Surplus

$$\Delta CS_h = \left\{\frac{x_h^g \bar{p}_h^g}{\varepsilon_h^g + 1}\left[1 - \left(\frac{p_h^g}{\bar{p}_h^g}\right)^{\varepsilon_h^g + 1}\right]\right\} + T_h$$

uncompensated own price elasticity of demand for gasoline

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mean price of gasoline
before the price change

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mean demand for gasoline *before* the price change

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lump-sum tax for policy simulations

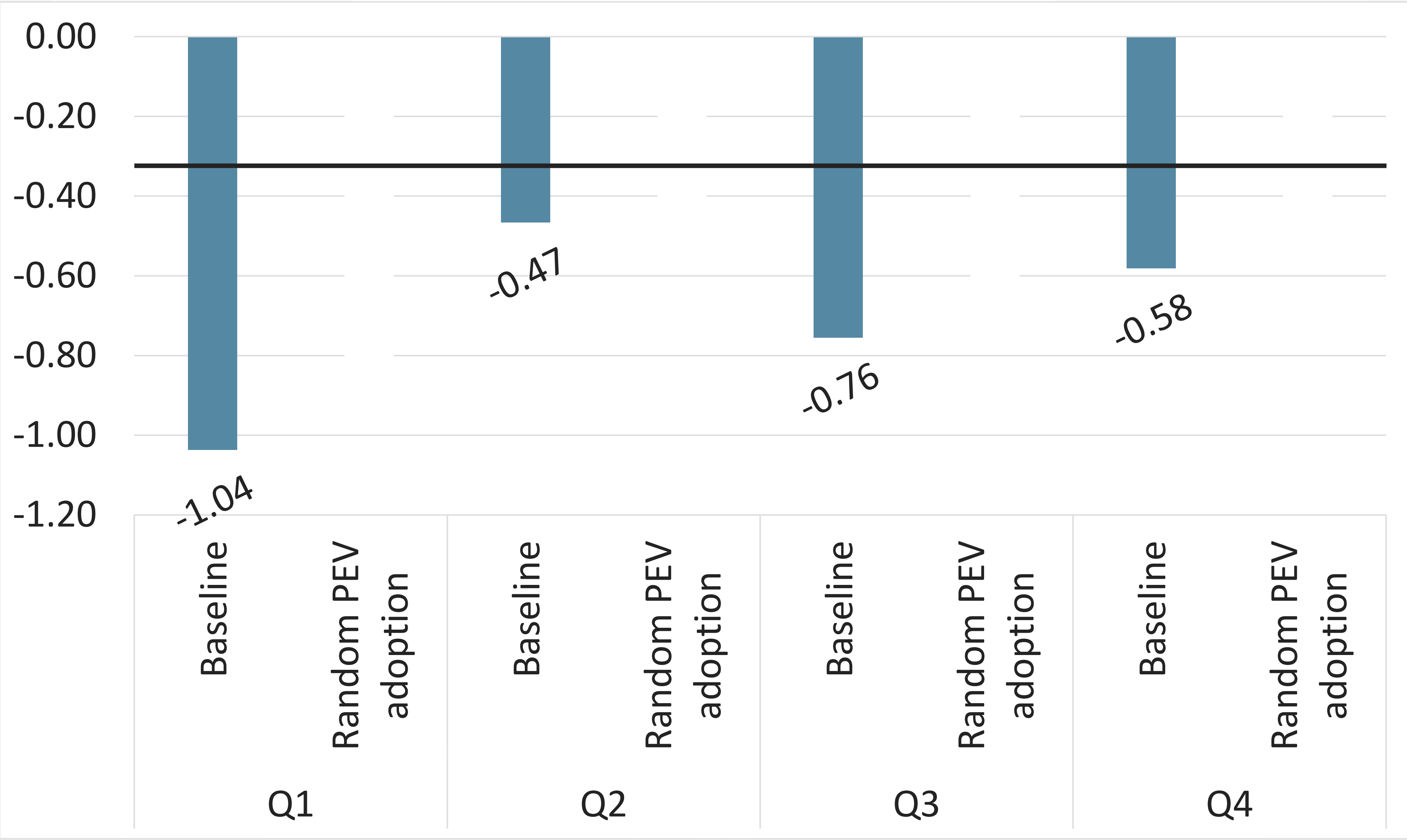
mean price of gasoline *after* the price change

Data

- Main Data Sources
  - Consumer Expenditure Survey (HH expenditures)
  - CCER Historic Cost of Living Indexes (prices as composite)
  - Federation of Tax Administrators (state gas taxes)

- Sample Construction
  - Include only adults between 18-64
    - most likely to be working and making use of automobiles
  - 10,692 one-adult HH 14,390 two-adult HH
    - 2-adult HH younger, more ed, more children, work more

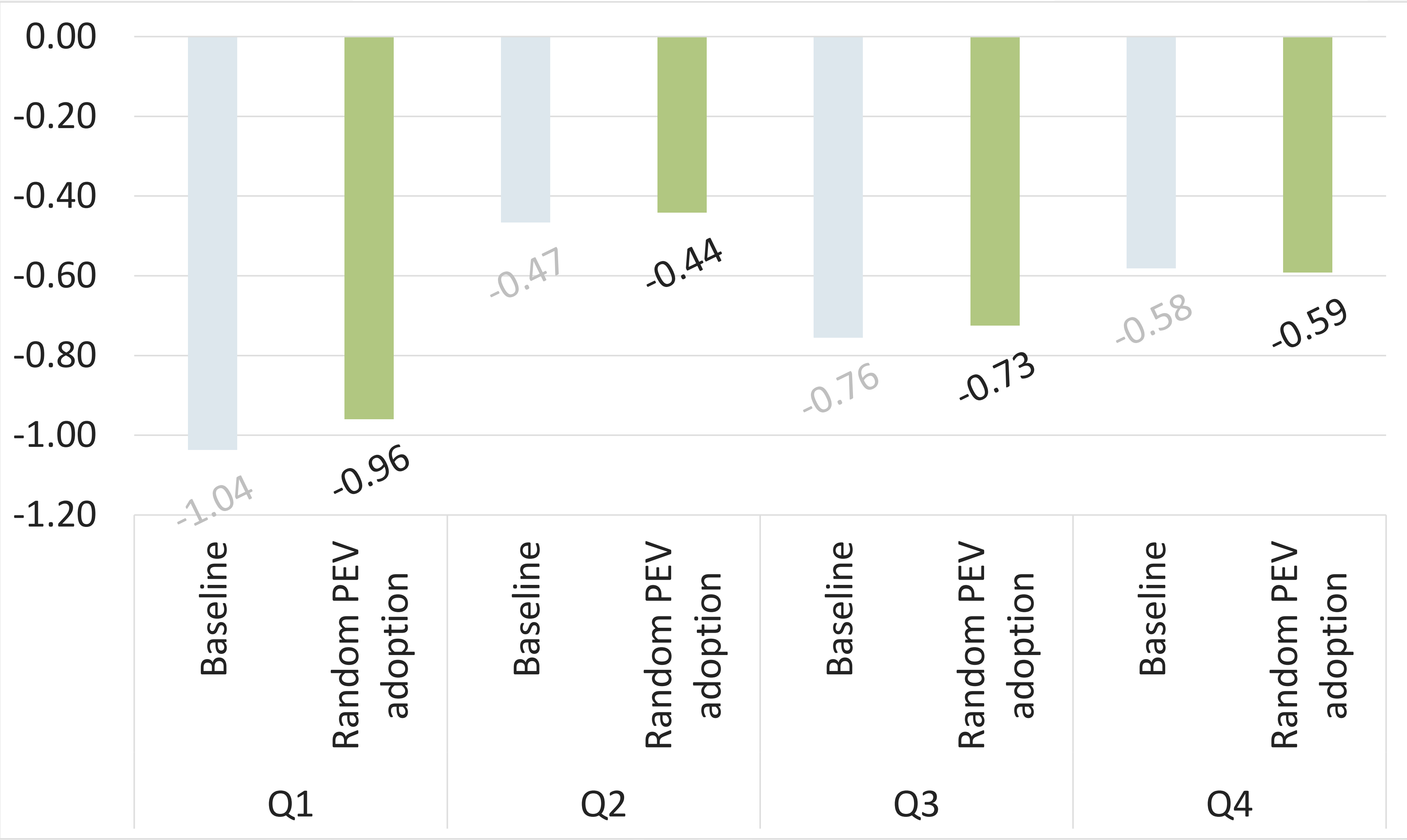
Estimation – uncompensated price elasticity



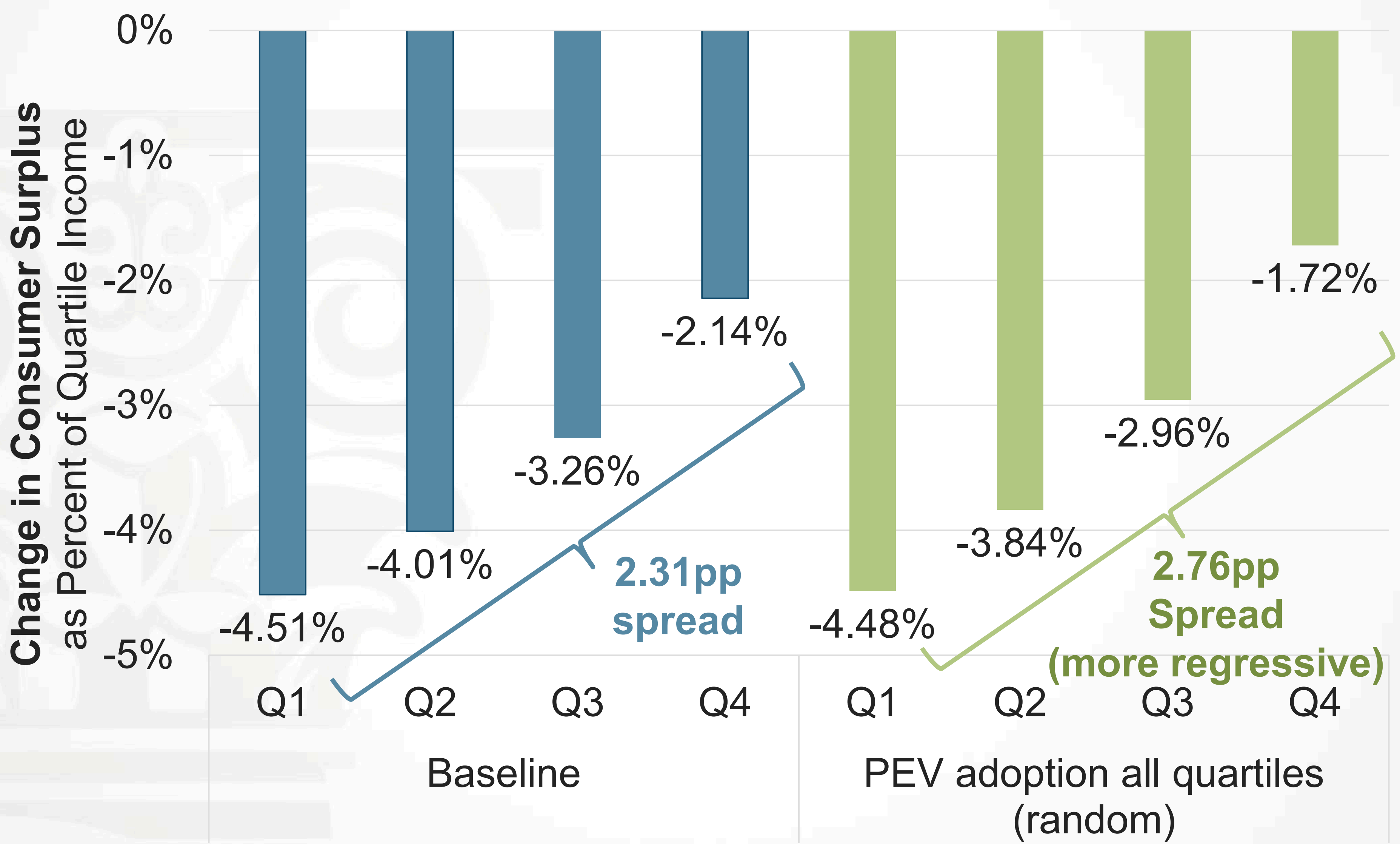
Estimation – Operationalizing PEV Adoption

- Fact: wealthy households are currently more likely to purchase PEVs than poorer households
- => Increase percentage of adoption with income
- By quartile, 2%, 5%, 10%, and 20% of HH adopt PEV
  - choose households at random
  - 25 random draws, average results across those 25 samples
- Decrease consumption of gasoline for PEV family by 99% of pre-adoption consumption
  - demand shifts from gasoline to "other"
- Re-estimate demand system to get new elasticity estimates for each draw

Estimation – uncompensated price elasticity



Simulation – Increase Gas Tax to $1.39



Simulation – Policy Alternatives

- Alternatives to raising the gas tax
  - Replace the gasoline tax with a lump-sum tax

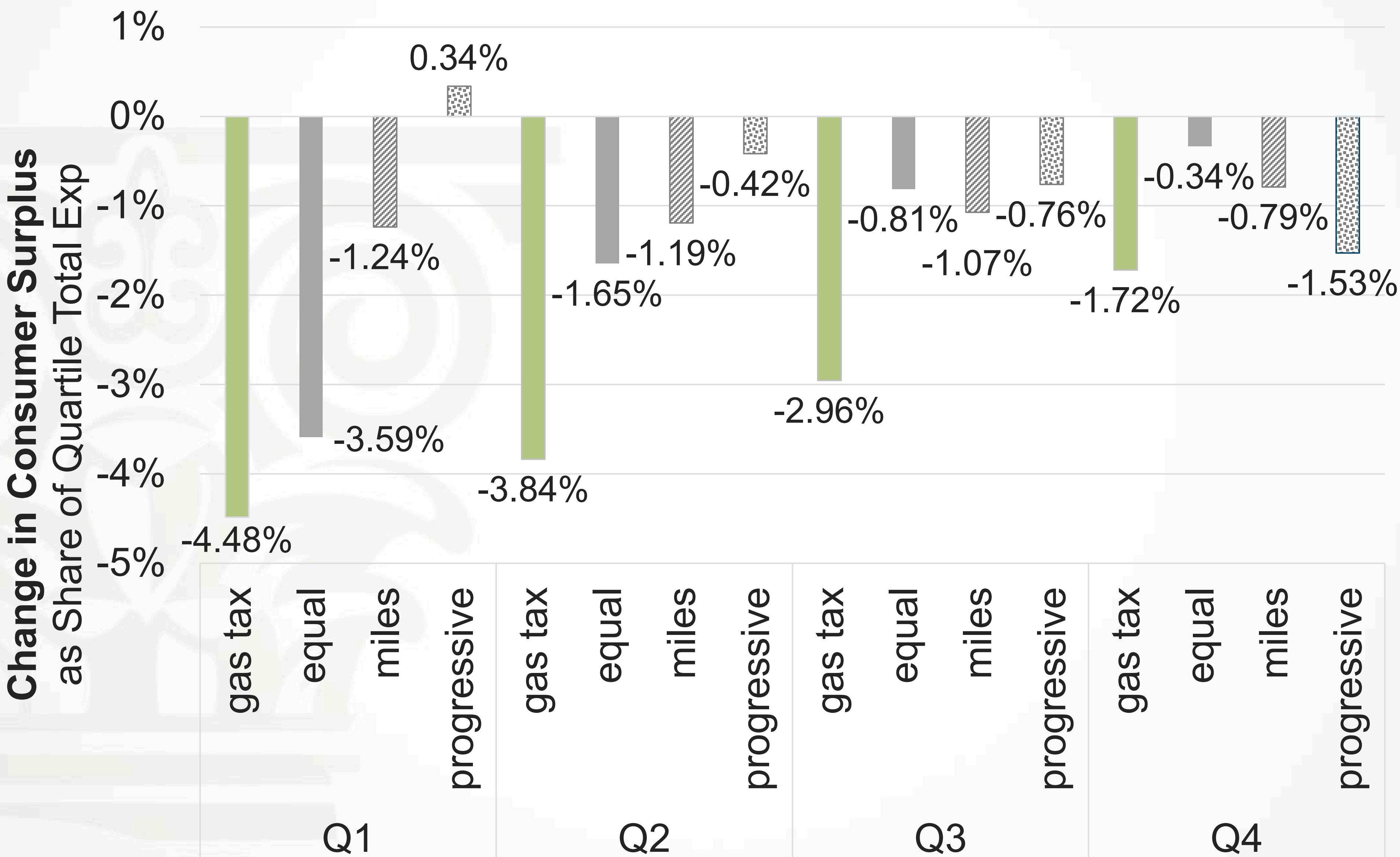
$$\Delta CS_h = \left\{ \frac{\bar{x}_h^g \bar{p}_h^g}{\varepsilon_h^g + 1} \left[1 - \left(\frac{p_h^g}{\bar{p}_h^g} \right)^{\varepsilon_h^g + 1} \right] \right\} + T_h$$

  - Raise the **same a revenue (*R*)** generated by a **$1.39** gas tax

$$\sum_h T_h = \sum_h \bar{x}_h^g * \$1.39 = R$$

- Consider three ways to assess the lump sum
  - $T_h = R/H$ (H = # households) ← revenue split equally across HHs
  - $T_h = \left(\bar{x}_h^g \bar{p}_h^g / \sum_h \bar{x}_h^g \bar{p}_h^g \right) * R$ ← lump sum based on share of gas consumed by HH
  - $T_h = (y_h / \sum_h y_h) * R$ ← lump sum based on HH's share of total income
- Q: How do these alternatives compare to raising gas tax in terms of regressivity?

Incidence of Different Policies



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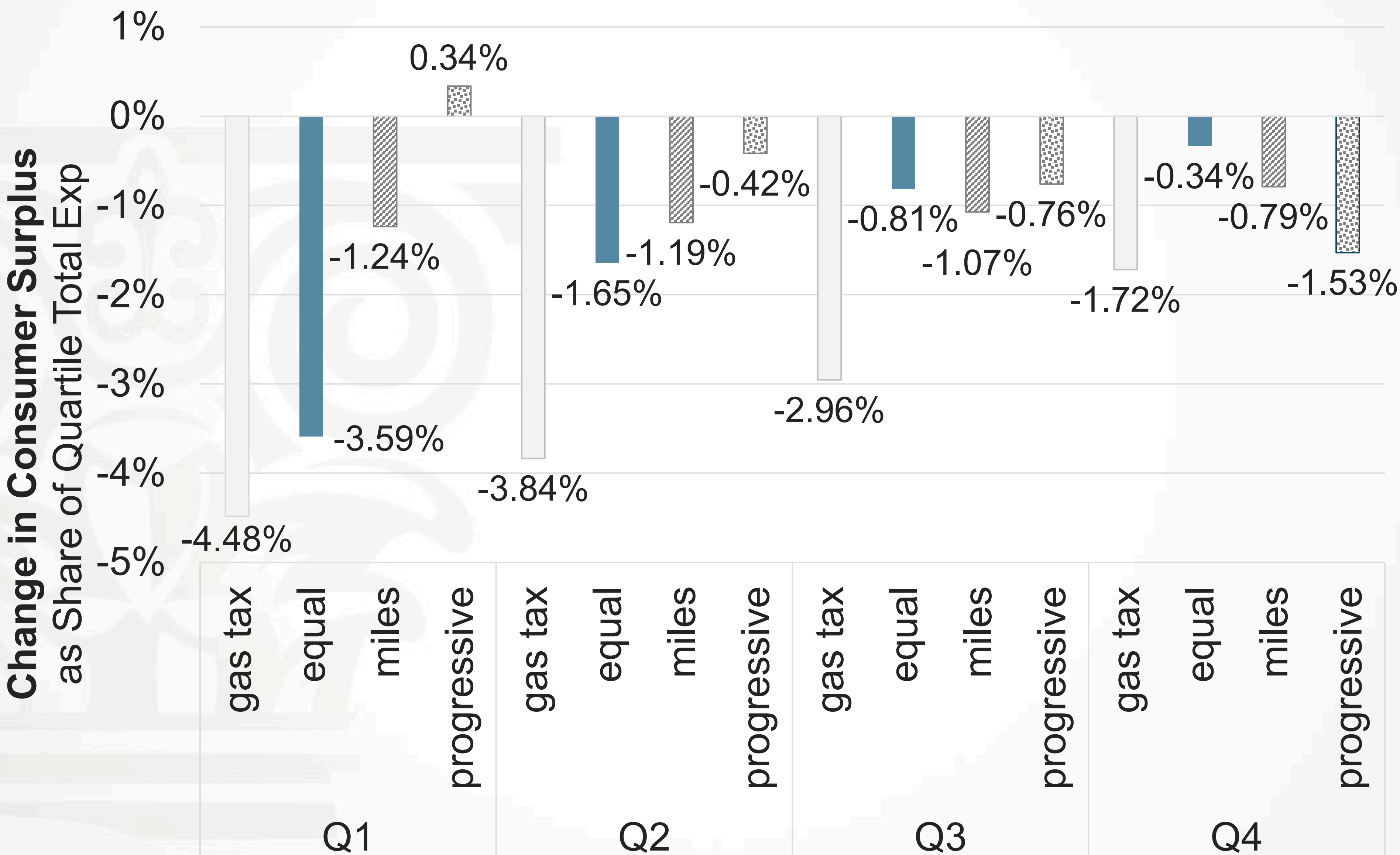

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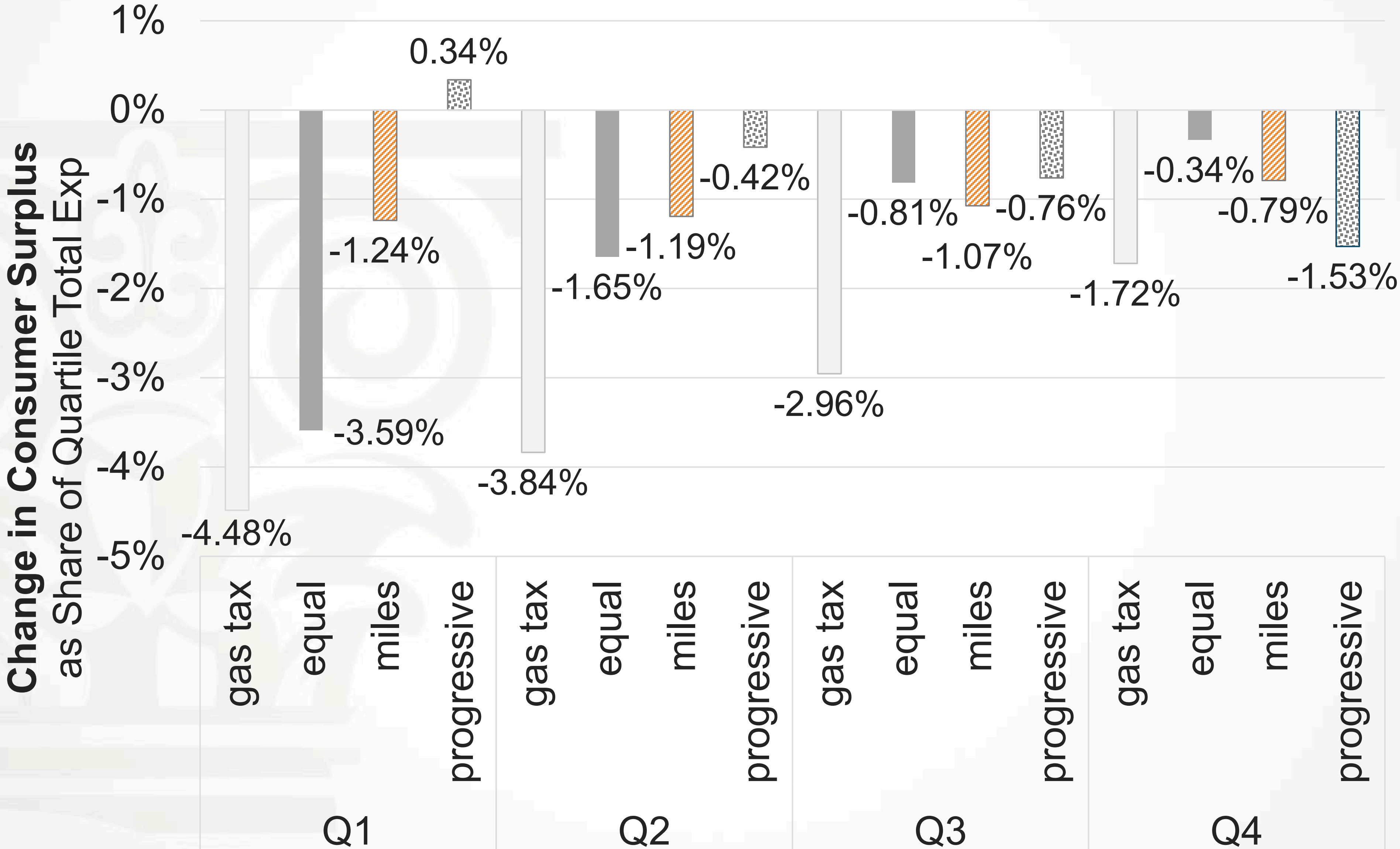

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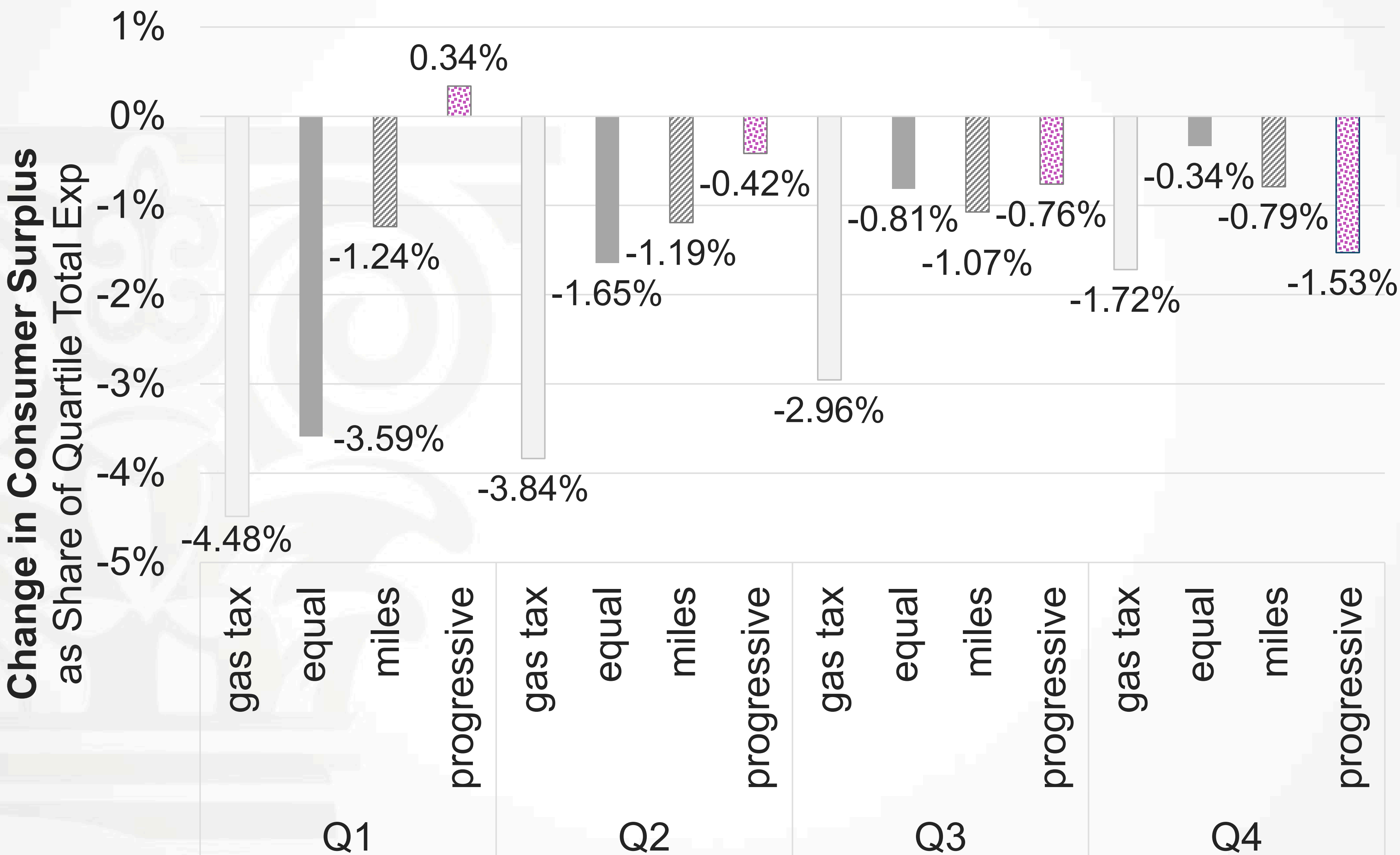

Conclusions

- Bottom Line
  - adoption of PEVs growing
  - additional revenues are needed to maintain infrastructure
  - any lump sum tax solution will leave consumers better off than an excise tax solution – options vary in terms of regressivity
- Reducing burden to lower-income families
  - convert the current PEV tax *credit* to a *refundable* tax credit
  - tie tax incentives (inversely) to income
  - improve charging infrastructure – especially rural
- *Policy Makers need to consider distributional implications of solutions for funding infrastructure*

National Haiku Poetry Day 4/17

EVs and potholes.
Who will pay as taxes rise?
Policy decides.

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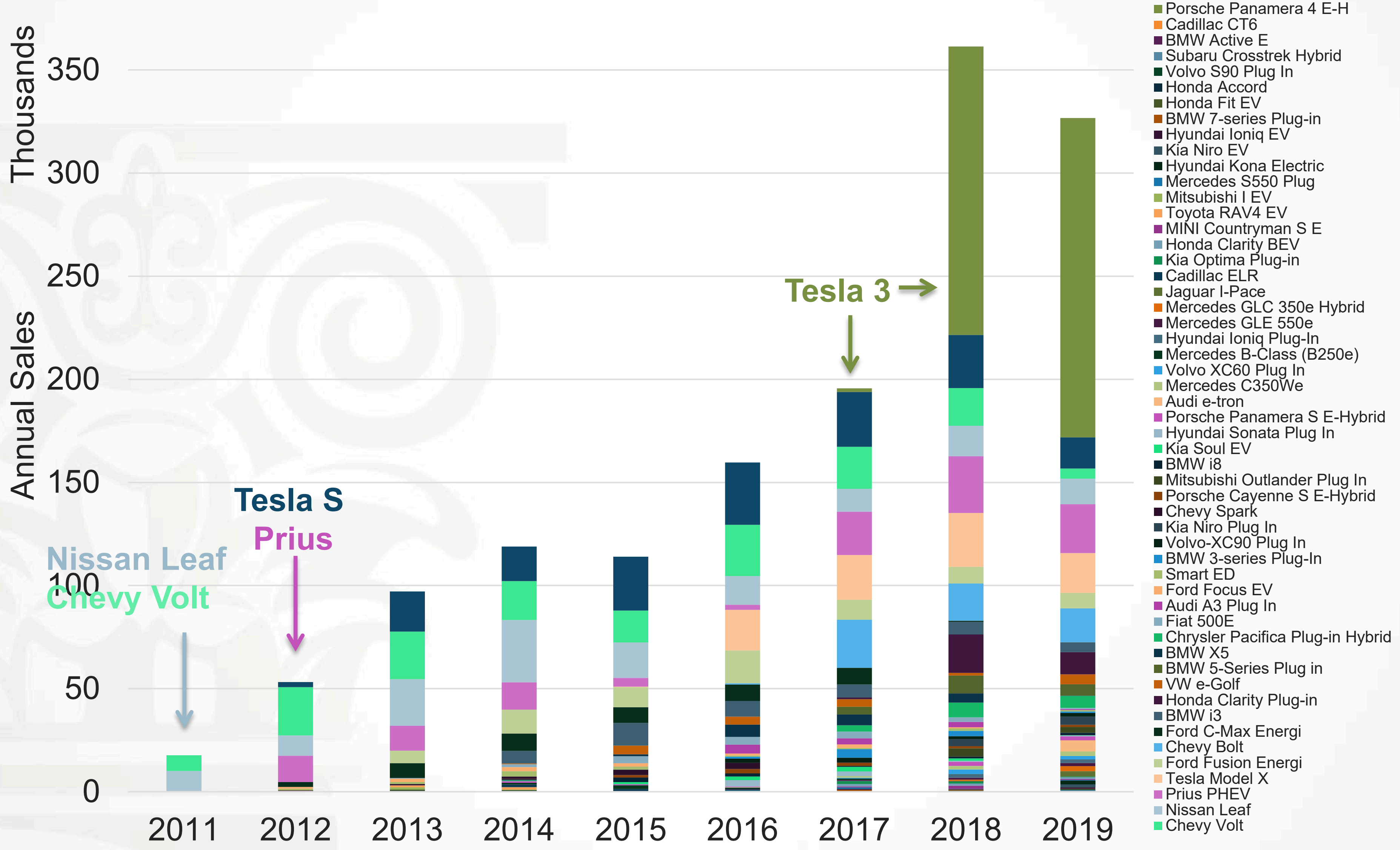
Thank you

Car Maker and State Actions

- **GM** plans to phase out production of all internal combustion engines by 2035
- **Daimler** (Mercedes-Benz) will be selling only carbon-neutral cars by 2039
- **Volkswagen**, **Nissan**, & **Ford** pledge to be carbon-neutral by 2050
- 2/3 of **Honda** sales will be electric or hydrogen by 2030
- No sales of gas-powered cars will be allowed in **California** after 2035 ⟵ *expanded to heavy trucks*
- All 2030 & later model vehicles sold, purchased, or registered in the state of **Washington** must be electric

Electric Vehicle Sales Quadrupled since 2011



Source: Alternative Fuels Data Center, https://afdc.energy.gov/data

Calculating Tax Incidence - Caveats

- Does not take into account cross-price elasticities
- Assumes constant price elasticity along demand curve
  - we are going to consider a rather large change in price
- Dollar-equivalent calculation is more complete
  - corresponds to area under the *compensated* demand curve
  - requires estimation of the indirect utility function
  - equivalent if income elasticity of demand is zero
- Errors should be mitigated for policy comparisons
  - considering the same price change in all scenarios
  - WW (using same large price increase) find only slightly different welfare effects comparing uncompensated and compensated demand
  - Hausman (1981) concludes uncompensated demand adequate for estimating impact on CS, but less so estimating deadweight loss

Data

- Consumer Expenditure Survey 2016-2018
  - nationally representative survey about HH spending habits, hours worked, demographics, and geography
  - HH surveyed up to 4 times
  - includes one- and two-adult HH and their children under 18
- Council for Community and Economic Research Historical Cost of Living Index
  - quarterly price information for period of analysis
- Current Population Survey
  - quarterly state unemployment rates
- Federation of Tax Administrators
  - state level gas taxes over time

Expenditure Shares

- One-adult HH consume more leisure, men in two-adult HH consumer more leisure than women

Household Type	One-adult	Two-adult
Leisure (singles)	0.72	
Leisure (married women)		0.31
Leisure (married men)		0.56
Gasoline	0.01	0.01
Other	0.26	0.12

Estimation – Preliminary Steps

- Sample includes only households who consume some non-zero amount of gasoline
  - to generalize results, we account for this selection by including a regressor to control for the family's propensity to consume gasoline
  - probit estimation of 0/1 gasoline purchase as function of total expenditures, prices, demographics – followed West & Williams (2007) specification
- Need to impute wages for non-workers (leisure price)
  - use predictive mean matching
  - Heckman selection wage equation estimation
  - match non-worker with worker on Heckman predicted wage
  - apply worker wage to matched non-worker

Simulation – increase gas price to $1.39

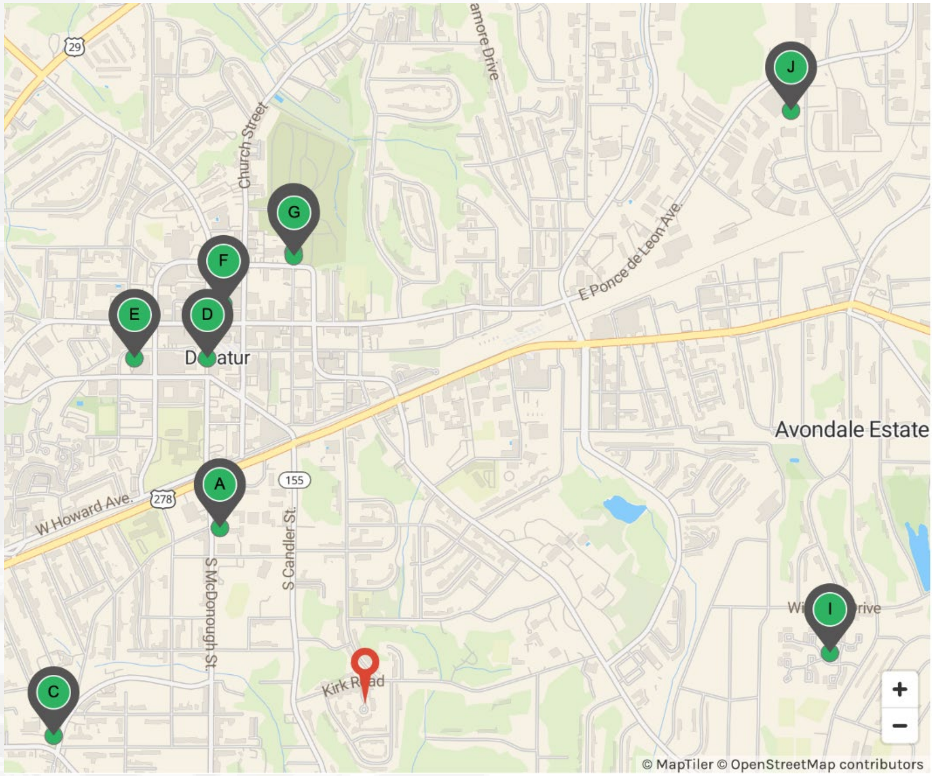
- West & Williams (2007) estimate the optimal tax that would account infrastructure externalities to be **$1.39**
  - this is a 600% increase over the current $0.184 Federal tax
- Simulate the change in **consumer surplus** (CS) that results from this price increase
  - under current demand for gasoline and under PEV adoption

Sample Construction

- Include only adults between 18-64
  - most likely to be working and making use of automobiles
- 10,692 one-adult HH 14,390 two-adult HH
  - 2-adult HH younger, more ed, more children, work more

Household Type	One-adult	Two-adult
Weekly gas expenditure	$15.84	$25.55
Quartile 1	12.26 (1.9%)	14.79 (0.4%)
Quartile 2	15.77 (1.5%)	21.27 (0.5%)
Quartile 3	16.61 (0.9%)	28.77 (0.6%)
Quartile 4	18.51 (0.5%)	37.37 (0.6%)

Charging infrastructure



Decatur, GA
nearest charging station
0.4 miles from home

Topton, NC
nearest charging station
14 miles from home