Fuel Economy and CO2 Emissions Standards, Manufacturer Pricing Strategies, and Feebates

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Background

- Costs and benefits of fuel economy standards are large
- Economic impact depends on cost of fuel economy technologies relative to fuel savings
- Insufficient cost effective technologies -> manufacturers price vehicles to change sales mix -> consumer surplus loss at the margin

Understand the effectiveness of the standards (1) role of technology adoption vs. pricing

- Manufacturer compliance options: technology adoption and pricing
- Why to study the role of technology adoption vs. pricing
  - Pricing has potentially important impacts on effectiveness of standards and consumer surplus
  - Few studies look at pricing and technology simultaneously over a long compliance period

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Understand the effectiveness of the standards (2) Interaction with feebate policies

- Interaction with feebate policies
  - Feebate: Fee + Rebate
    - Fees on purchase of new vehicles with low fuel efficiency
    - Rebates to purchase of new vehicles with high fuel efficiency
- Impact of feebates on emissions reduction and manufacturer pricing strategies

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Understand the effectiveness of the standards (3) Fuel efficiency rebound effect

- Fuel efficiency rebound effect
  - If fuel inefficient vehicles become more fuel efficient, there might be a shift of sales toward fuel inefficient vehicles.
  - Not VMT (vehicle miles travelled) rebound effect
  - Fuel efficiency rebound effect erodes fleet fuel economy improvement and emissions reduction

Overall Approach

- An optimization model that simulates manufacturer decisions of technology adoption and pricing while meeting the standards and considering consumer response
- Data:
  - Vehicle sales
  - Technology cost curves

Approach: a dynamic optimization model that simulate manufacturer decision & consumer response

- Decision variables: emissions rate (e_i^t), price adjustment (Δp_i^t)
- Objective: maximize social surplus

$$\max \sum_t \{(1+r)^{-t} MS(t)[\Delta CS(t) + S_{Buy}(t) \sum_i S_i(t) \Delta p_i(t)]\}$$

- Constraints: emissions standards and redesign cycle restriction

$$\sum_{i=1}^{N} S_i(t) e_i(t) \leq \sum_{i=1}^{N} S_i(t) e_i^*(t) \text{ , } \forall t,$$

- Consumer demand is estimated by a nested logit model
  - The nesting structure has 5 levels
  - Calibrated to 2007 sales data and price elasticities in the literature

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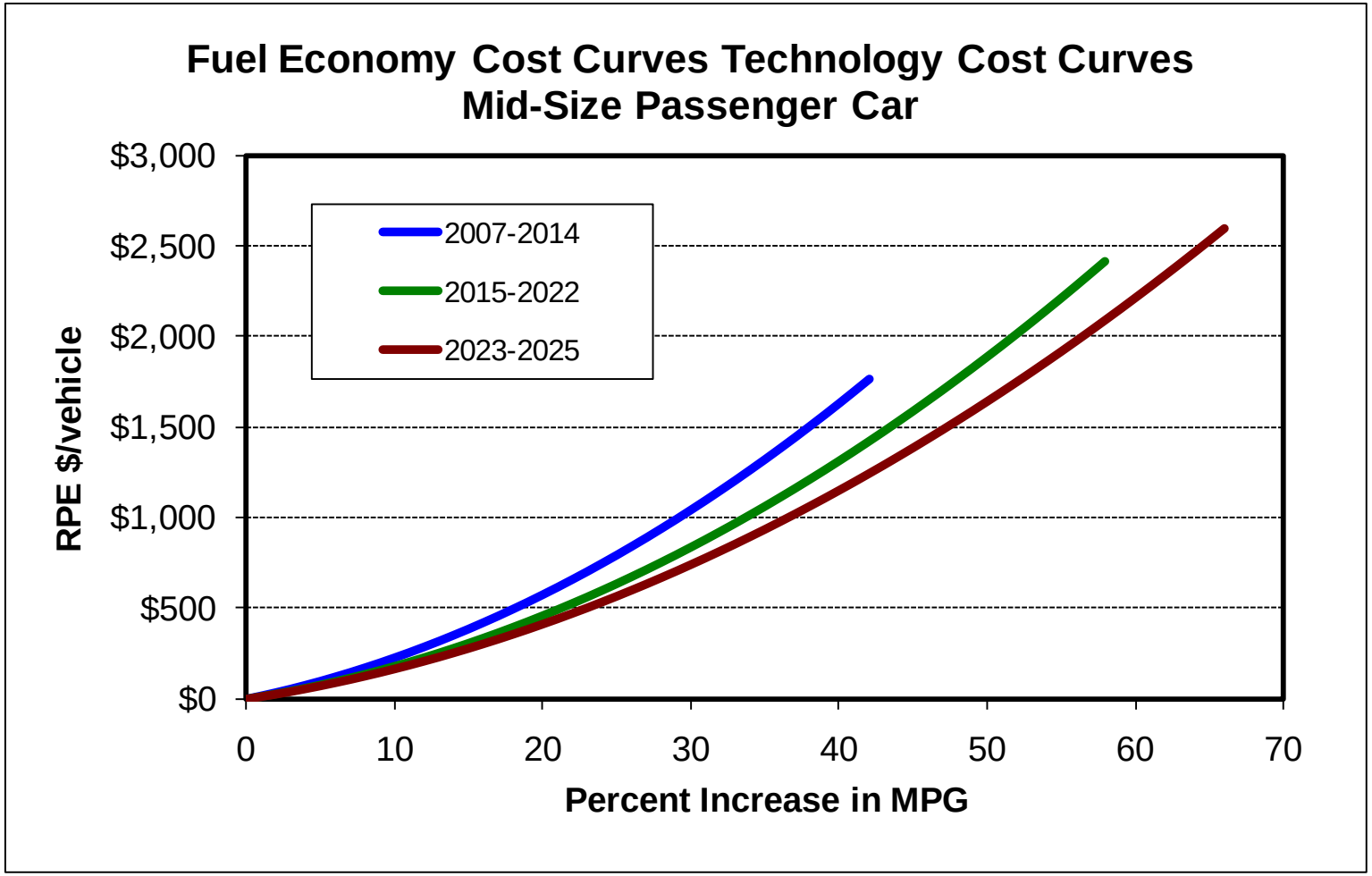
Approach: Optimality conditions

- Revenue from pricing is zero: $\sum_i S_i\,(t)\Delta p_i(t)$=0
- Optimal pricing strategy:

$$\Delta p_i(t) = \lambda(t)\,(e_i(t) - e_i^*(t))$$

  - $\lambda(t)$ pricing rate: proportional to shadow price of emissions standards constraints
  - Pricing is like a manufacturer internal feebate with $\lambda(t)$ as feebate rate

The technological potential to increase fuel economy/reduce emissions was represented by cost curves



Planning period: 2011-2020; Reference and policy cases

1. Compare reference case with base policy case
   - Reference case: no standards
   - Base policy case: standards in place; Air conditioning(AC) and flex-fuel vehicle (FFV) credits are allowed; No banking;

2. Sensitivity analysis

No AC and FFV Credits	Base case assumptions & No AC and FFV credits
Banking	Base case assumptions & allowing banking
Low Hybridization Cost	Base case assumptions & lower hybridization cost
Low Price Elasticity	Base case assumptions & lower price elasticities
High Price Elasticity	Base case assumptions & higher price elasticities

3. Feebate case
   - Base case assumptions & a feebate program with $20/gram co2/mile for 2011-2020

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The proportion of emissions reduction due to pricing is small for all cases except the case of No AC and FFV Credits

Scenario Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Base						4.2%			4.2%	5.3%
No AC and FFV Credits		22.0%			9.0%	10.0%		2.7%	6.5%	6.4%
Banking				2.9%	4.4%	3.8%	2.0%		1.0%	1.8%
Low Hybridization Cost					0.8%	2.2%			0.4%	
Low Elasticity						3.7%			3.4%	4.4%
High Elasticity						4.6%			5.0%	6.2%
Feebates										

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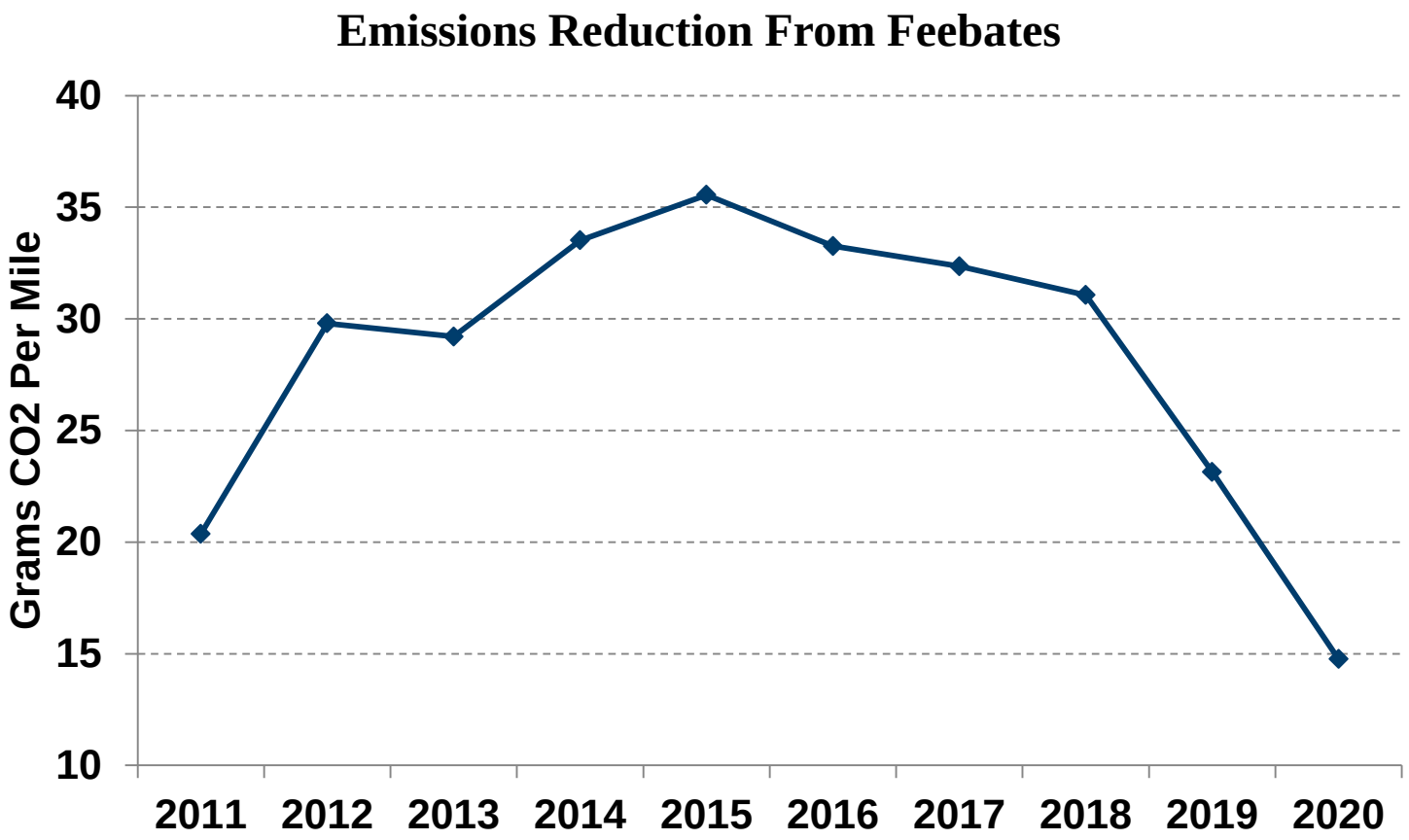
A feebate program with $20/gram CO2 /mile can reduce emissions by 20-30 gram CO2/mile relative to the base case, but the benefit diminishes in the outer years when feebates act as a replacement of pricing.



Quantify fuel efficiency rebound effect

- Fuel efficiency (emissions rate) e_i^0, market share S_i^0 in the reference case
- Fuel efficiency (emissions rate) e_i^1, market share S_i^1 in a policy case
- Rebound effect = $\frac{\sum S_i^1 e_i^1 - \sum S_i^0 e_i^1}{\sum S_i^1 e_i^1}$

No fuel efficiency rebound effect for most years of the cases; The scale of rebound is small even when it does exist. (Positive numbers indicate a rebound effect)

Scenario Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Base	0.1%					-4.4%	-0.1%		-4.5%	-5.8%
No AC and FFV Credits	-12.5%	-30.2%		-0.2%	-10.1%	-11.4%	-0.4%	-3.1%	-7.3%	-6.9%
Banking	0.3%	0.1%	-0.1%	-2.5%	-5.6%	-4.9%	-2.7%	-0.1%	-1.0%	-2.3%
Low Hybridization Cost				0.1%	0.2%	-0.8%	0.2%	0.2%	0.3%	0.6%
Low Elasticity	0.1%					-3.9%	-0.1%	0.0%	-3.6%	-4.8%
High Elasticity	0.1%					-4.8%	-0.1%	0.0%	-5.4%	-6.9%

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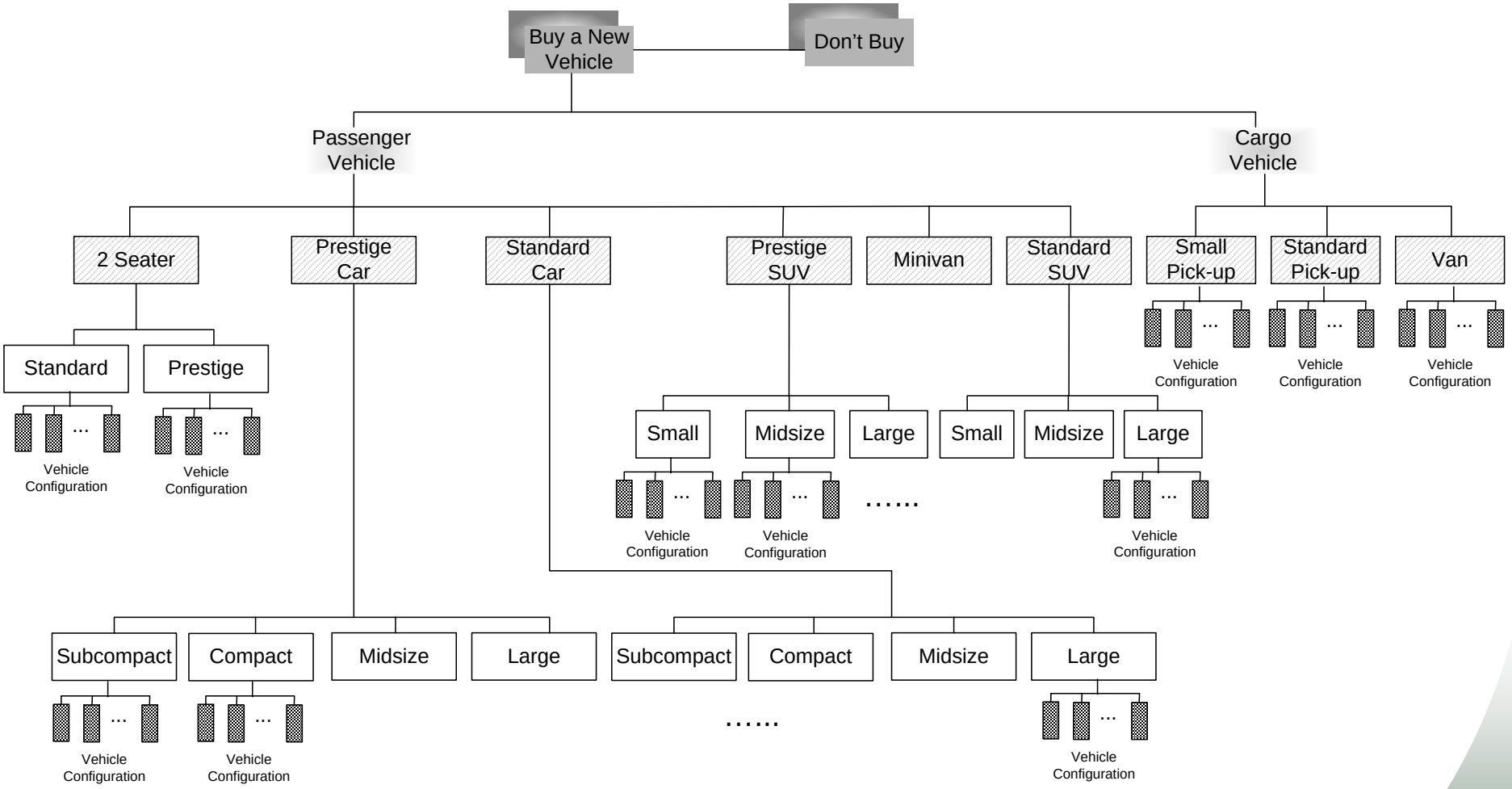
Summary of findings

- Technology adoption plays the major role in meeting new fuel economy and emissions standards
- Pricing is minor but may be used in outer years if cost-effective technologies are less plentiful.
- Importance of flexibility mechanism in meeting standards
- The new standards are unlikely to produce a fuel efficiency rebound effect
- Feebates can bring additional emissions reduction, but the benefit may diminish over time if feebates act as a replacement for manufacturers' pricing strategies

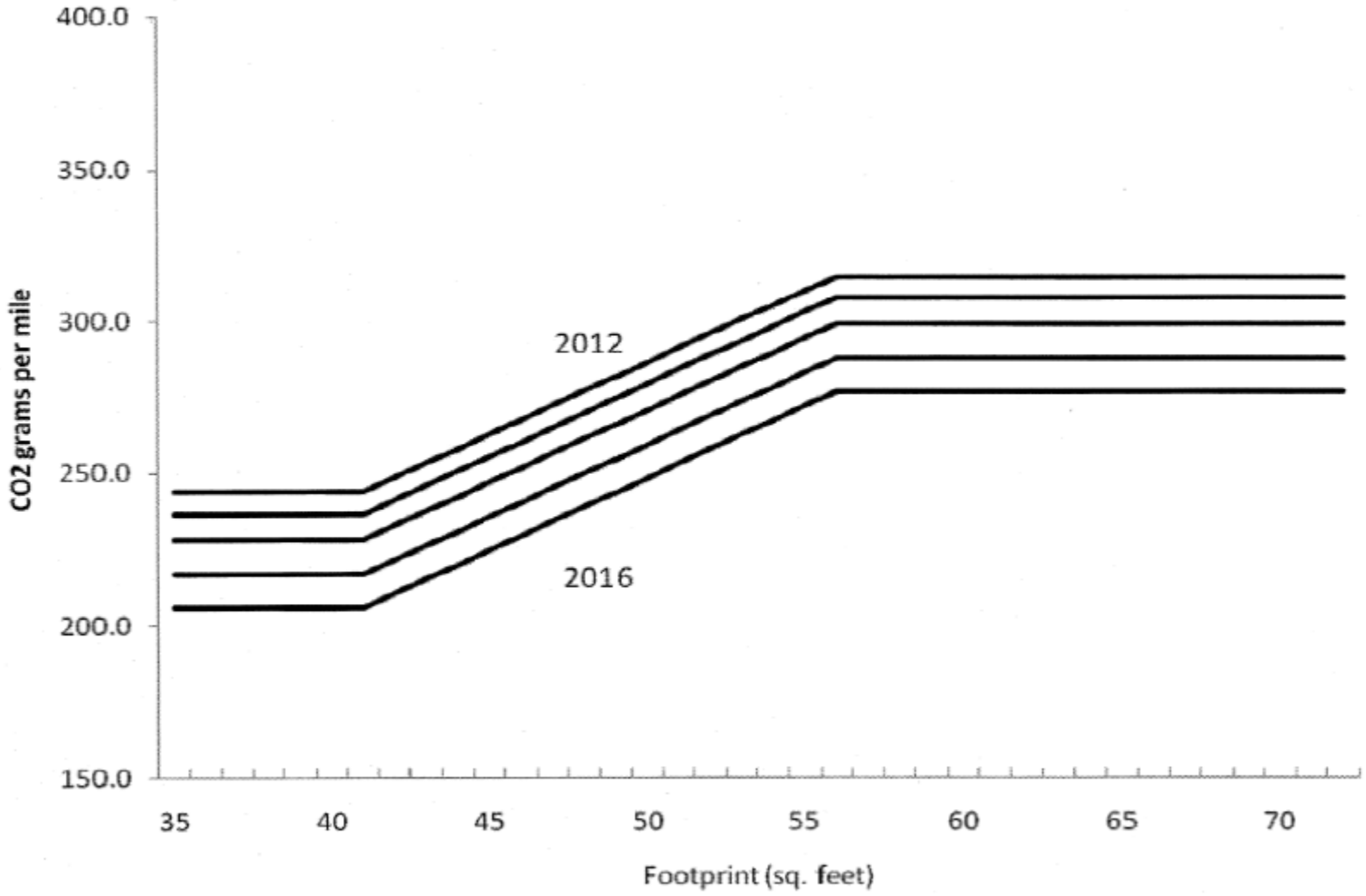
Thank you!

SUPPLEMENTAL SLIDES

Approach – a nested multinomial logit model that simulates consumer response to changes in vehicle prices and operation costs



US light duty vehicle emissions standards



Approach: modeling hybridization decision

- Hybridization: convert an existing gasoline vehicle to a hybrid electric vehicle.
- Trade-off between increased vehicle cost (hybridization cost) and improved fuel efficiency
- Binary decision variables to model which vehicles will be hybridized and when

Value of manufacture pricing rate ($\lambda(t)$) in different scenarios

Scenario Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Base						4.8			12.4	19.6
No AC and FFV Credits		9.0			12.4	16.7		10.5	30.0	34.9
Banking				2.2	5.9	6.0	5.7		2.1	5.4
Low Hybridization Cost						2.6			0.3	
Low Elasticity						5.3			12.6	20.5
High Elasticity						4.4			12.1	18.9
Feebates										