Re-Searching for Hidden Costs with Producer Heterogeneity:

Evidence from the Adoption of Fuel-Saving Technologies in Light-Duty Vehicles

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Are there hidden costs as a result of adoption of fuel-saving technologies?

- A variety of fuel-saving technologies have been implemented recently under the EPA light-duty vehicle greenhouse gas emissions standards
- Questions have been raised about whether there are hidden costs
- Hidden costs are undesirable impacts of operational characteristics, including:
  - Drivability: Acceleration, handling, braking
  - Ride comfort, noise, vibration
- If hidden costs exist, they might contribute to an explanation of the existence of the energy-efficiency gap in the light-duty vehicle market

Previous work did not find systematic evidence of hidden costs associated with fuel-saving technology

- Empirical challenge: Operational characteristics are not easy to measure and quantify
- Helfand et al. (2016), *Energy Policy*:
  - Using content analysis of online auto reviews for Model Year 2014 (MY 2014) vehicles
    - Systematic coding of text to identify evaluations of both technologies and operational characteristics
- This study:
  - Replicates the work of MY 2014, to see if results hold using updated MY 2015 data and pooled MY 2014 & MY 2015 data
  - Looks for differences in results between the two years

Sampling and coding rules in the content analysis

- Sampling from professional auto reviews on websites
  - Popular websites, which have monthly unique views not less than one million
  - The reviewed vehicle is test driven
  - The review evaluates some technological features, beyond a basic specification sheet
  - The review has some independent assessment of vehicle operational characteristics
- Well-trained coders

Reviewed efficiency technologies and operational characteristics are coded as positive, negative, or neutral for each auto review

- “Acceleration from the V6 is quiet and strong, with the 6-speed automatic transmission gliding smoothly through its gears. ”
  - Positive for high-speed automatic transmission
  - Positive for general engine
  - Positive for acceleration capability
  - Positive for powertrain noise
- “We like the effortless power and the smooth transmission, but the auto start/stop system has more delay than some, the throttle can be a bit on the jumpy side and the light steering is disconcerting. ”
  - Negative for stop/start
  - Positive for high-speed automatic [transmission type noted elsewhere]
  - Positive for acceleration capability
  - Negative for steering feel-controllability-responsiveness

What we coded: Efficiency technologies

Efficiency Technology Categories		Coding Level
Active Air Dam		Active Air Dam
Active Grill Shutters		Active Grill Shutters
Active Ride Height		Active Ride Height
Low Resistance Tires		Low Resistance Tires
Elec Assist Or Low Drag Brakes		Elec Assist Or Low Drag Brakes
Lighting-LED		Lighting-LED
Mass Reduction		Mass Reduction
Passive Aerodynamics		Passive Aerodynamics
Powertrain	Engine	Electronic Power Steering
		Turbocharged
		GDI
		Cylinder Deactivation
		Diesel
		Hybrid
		Plug-In Hybrid Electric
		Full Electric
		Fuel Cell
		Stop-Start
	Transmission	High Speed Automatic
		CVT
		DCT

What we coded: Operational characteristics

Feature Type		Feature
Drivability	Handling	Steering feel/Controllability/Responsiveness
		General Drivability
		General handling
	Acceleration	Acceleration feel/Smoothness/Responsiveness
		Acceleration capability/Power/Torque
		General acceleration
	Braking	Brake feel/Responsiveness
		Stopping ability
		General Braking
Noise		Tire/Road
		Wind
		Interior
		Powertrain
		General noise
Vibration		Chassis
		Powertrain
		General vibration
Ride comfort		Ride comfort
Fuel economy		Fuel economy
Range		Range
Charging		Charging
Overall		**Qualitative Assessment (buy or not to buy)**

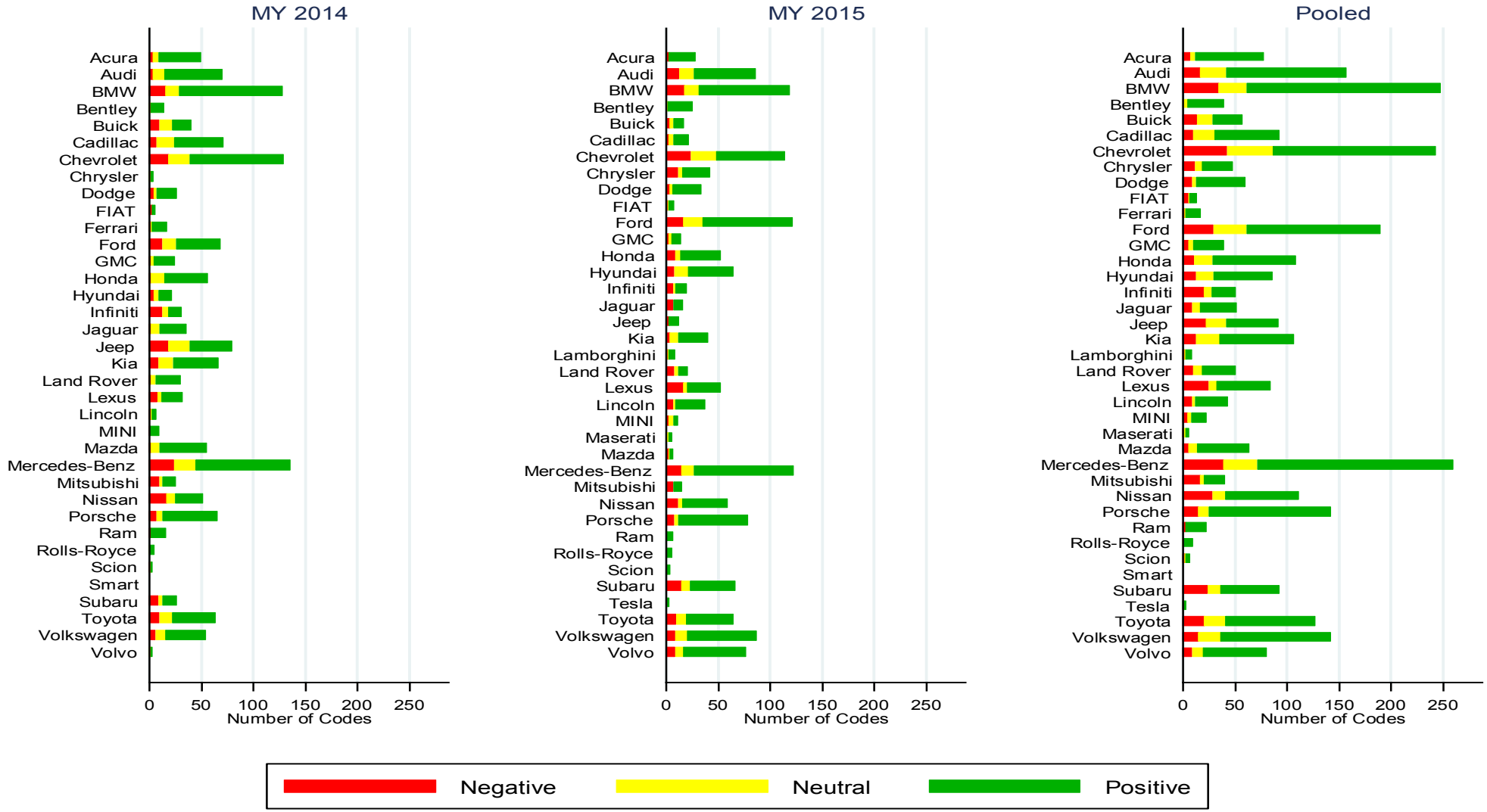
Seven popular professional auto review websites were selected

Website	MY 2014		MY 2015		Pooled	
	Review count	%	Review count	%	Review count	%
automobilemag.com	144	14	138	11	282	13
autotrader.com	224	22	336	27	560	25
caranddriver.com	216	22	202	16	418	19
cars.com	--	--	90	7	90	4
consumerreports.org	86	9	79	6	165	7
edmunds.com	112	11	105	9	217	10
motortrend.com	221	22	285	23	506	23
Total reviews	1,003	100	1,235	100	2,238	100

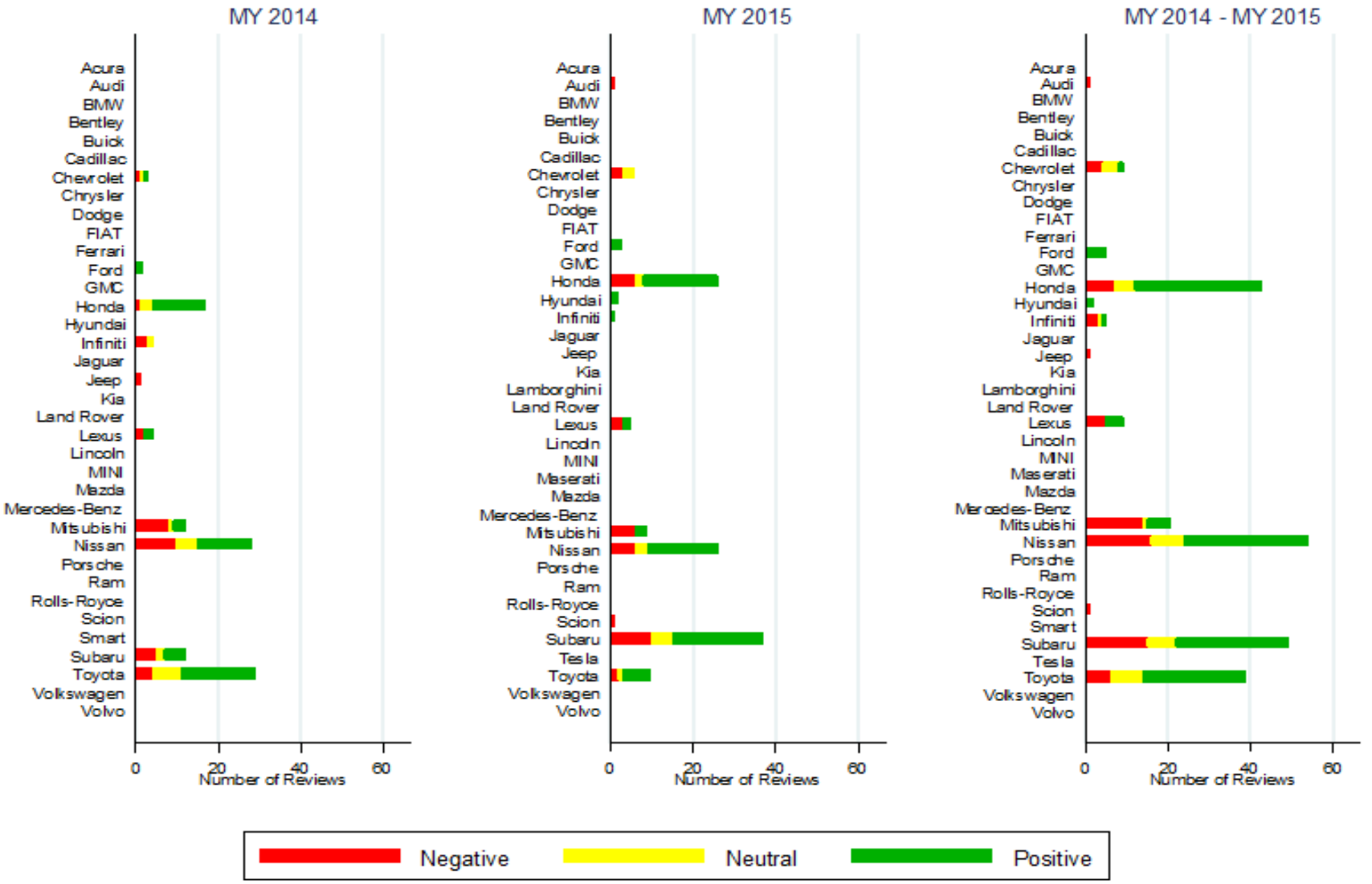
Reviews with positive evaluations substantially outnumber those with negative evaluations for the technologies examined

	MY 2014			MY 2015			Pooled		
	Negative review		Total	Negative review		Total	Negative review		Total
Efficiency Technology	Count	%	Count	Count	%	Count	Count	%	Count
Active Air Dam	0	0%	6	0	-	0	0	0%	6
Active Grill Shutters	0	0%	1	1	14%	7	1	13%	8
Active Ride Height	0	0%	3	0	-	0	0	0%	3
Low Resistance Tires	4	24%	17	4	31%	13	8	27%	30
Elec Assist Or Low Drag Brakes	1	14%	7	0	0%	2	1	11%	9
Lighting-LED	1	5%	20	0	0%	26	1	2%	46
Mass Reduction	0	0%	74	3	6%	48	3	2%	122
Passive Aerodynamics	4	10%	40	2	11%	19	6	10%	59
Electronic Power Steering	45	22%	208	22	14%	157	67	18%	365
Turbocharged	20	9%	223	43	13%	342	63	11%	565
GDI	6	9%	66	4	6%	65	10	8%	131
Cylinder Deactivation	1	3%	35	4	16%	25	5	8%	60
Diesel	7	12%	60	5	28%	18	12	15%	78
Hybrid	16	23%	71	10	21%	47	26	22%	118
Plug-In Hybrid Electric	4	14%	28	4	22%	18	8	17%	46
Full Electric	2	9%	22	0	0%	20	2	5%	42
Fuel Cell	0	-	0	0	0%	1	0	0%	1
Stop-Start	14	27%	51	15	31%	48	29	29%	99
High Speed Automatic	60	14%	414	96	20%	482	156	17%	896
CVT	35	31%	112	38	30%	127	73	31%	239
DCT	16	24%	68	18	17%	105	34	20%	173
Total	236	16%	1,526	269	18%	1,570	505	17%	3,096

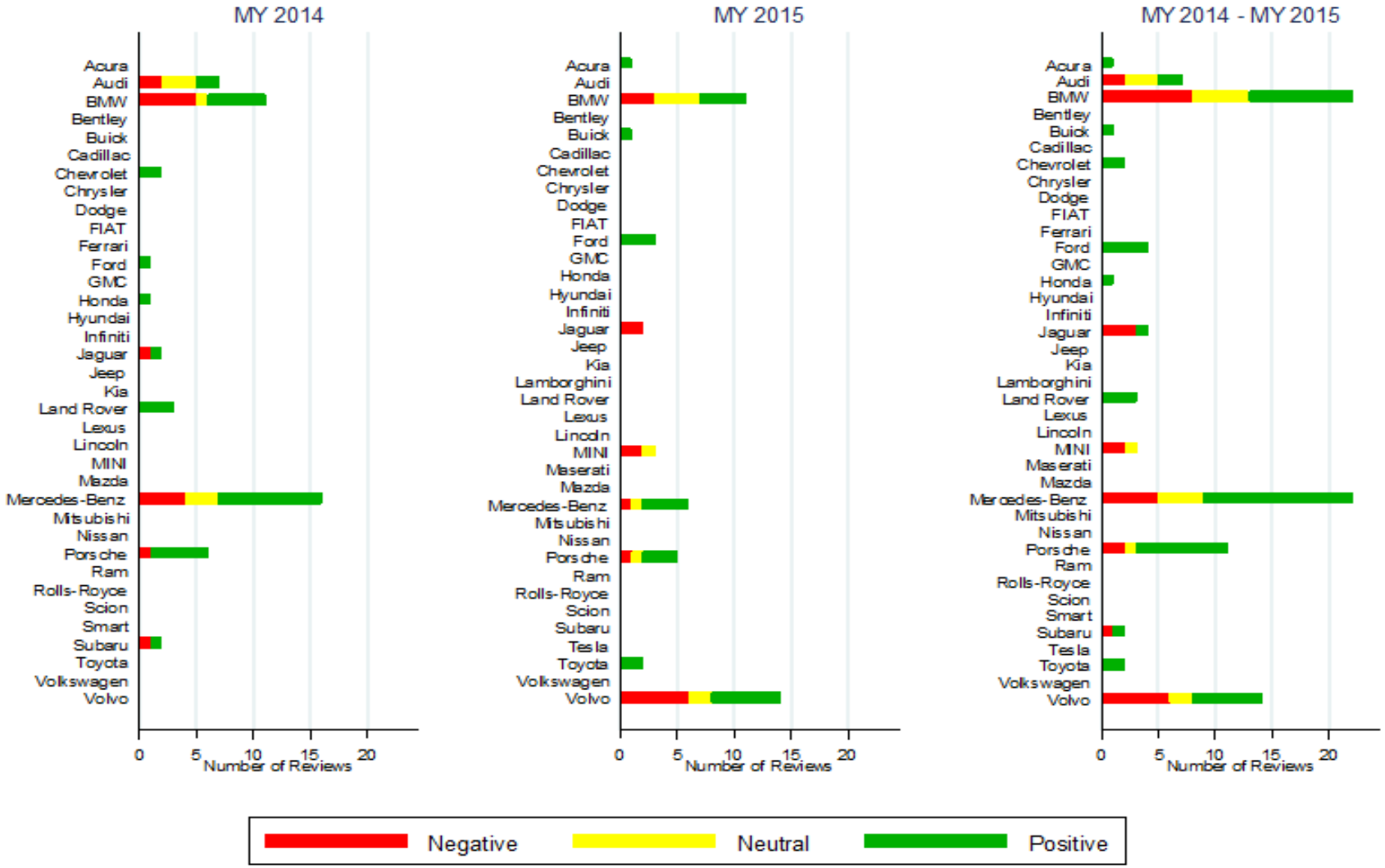
Review results of efficiency technology are heterogeneous by automaker



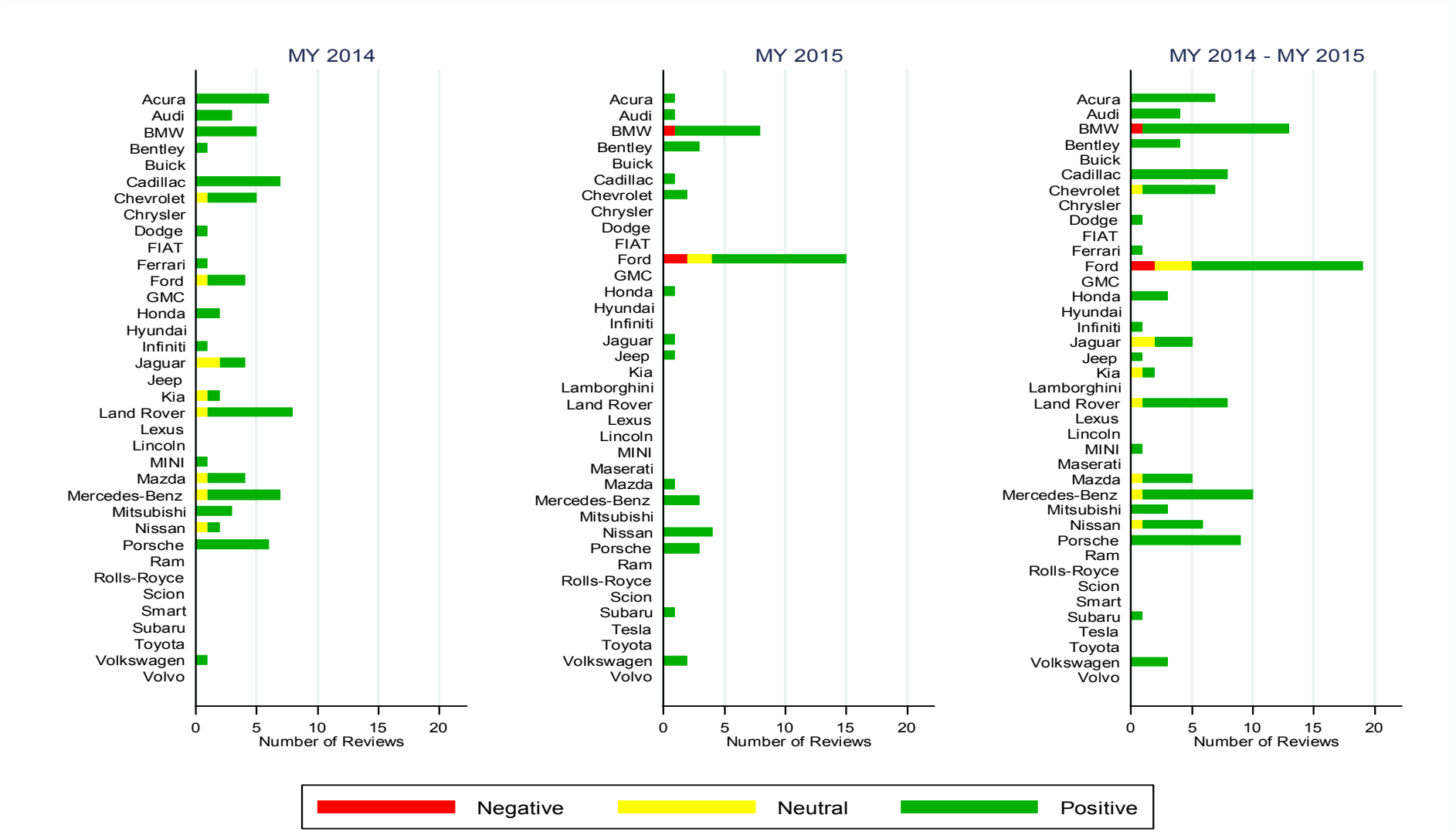
Great variation of review results of CVT by automaker



Great variation of review results of stop-start by automaker



Small variation of review results of mass reduction by automaker



Linear probability model used to estimate the relationships of efficiency technology and the probability of negative review for each operational characteristic

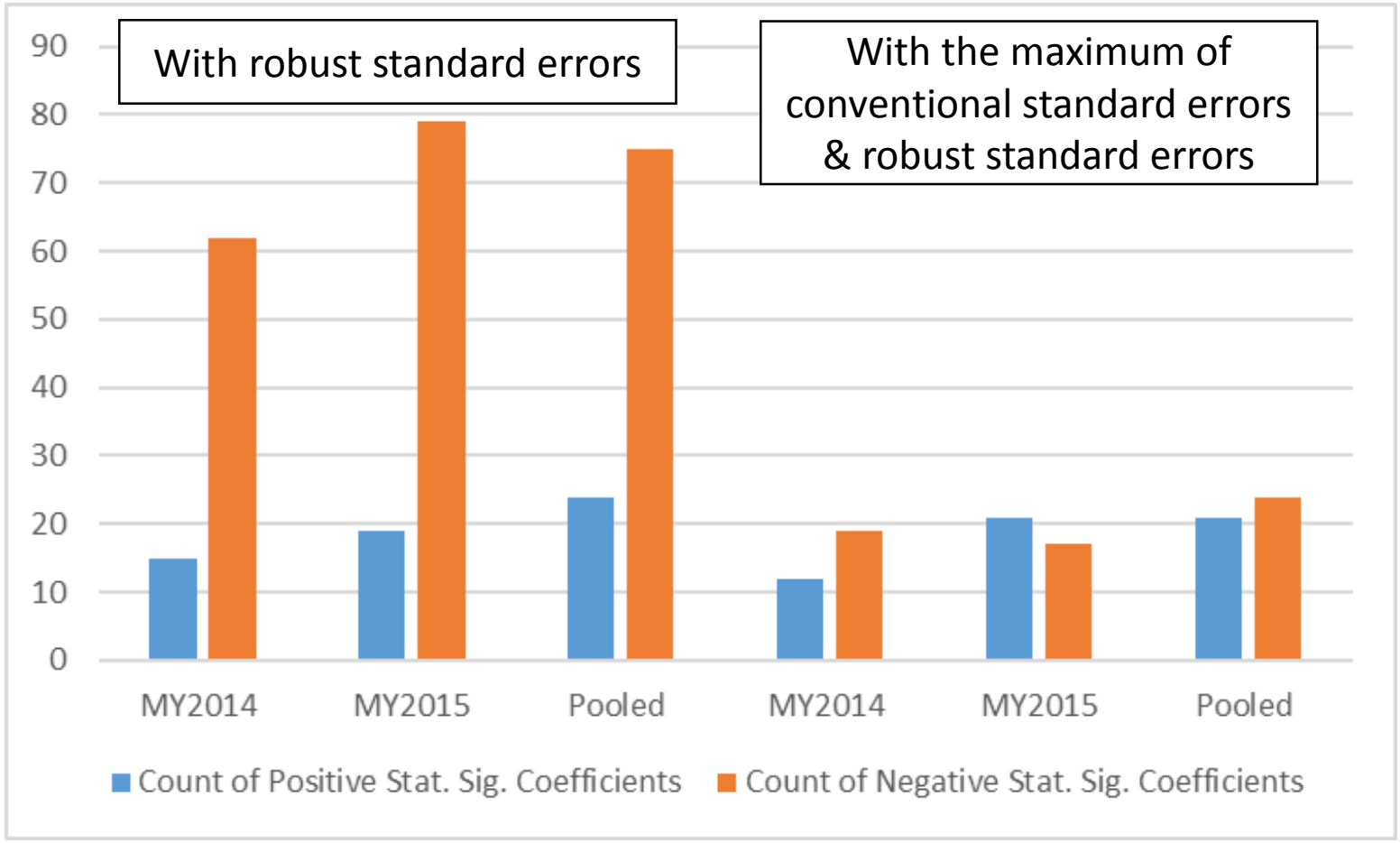
$$P(NegReview_{i,j,t}) = \sum_{k} \beta_k \, 1(ReviewTech_{i,k,t}) + FixedEffects + \epsilon_{i,j,t}$$

- i: auto review; t: year
- $NegReview$ = 1 if a negative evaluation coded for an operational characteristic j, otherwise 0
- $ReviewTech$ = 1 if an evaluation coded for an efficiency technology k, otherwise 0
- $FixedEffects$ include website, class, make, **year, website-by-year, class-by-year, and make-by-year** fixed effects

The relationship between a technology and the negative review of an operational characteristic

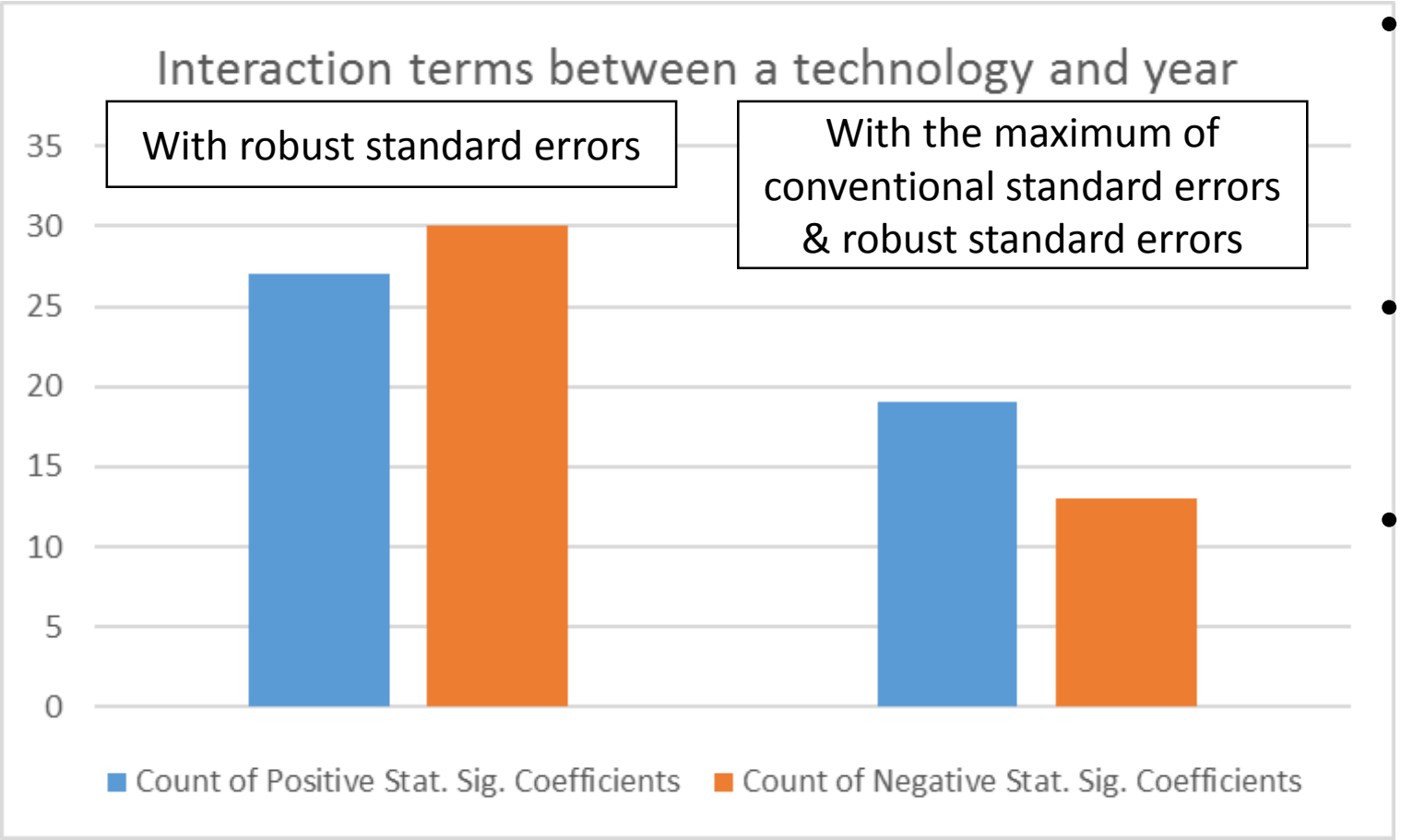
- In the slides that follow, we will emphasize statistically significant coefficients
- If a coefficient is statistically significant and positive, it increases the likelihood of a negative review – a hidden cost
  - A negative coefficient suggests that the characteristic is better in its presence
- We present results based on two estimates of standard errors
  - Robust standard errors, used for non-constant error variance with linear probability models
  - The maximum of the conventional standard error and a robust standard error, suggested by Angrist and Pischke (2009) as they argue robust standard errors may be smaller than conventional standard errors due to small sample bias

Out of 462 coefficients of technology, only about 20 coefficients are statistically significant and positive



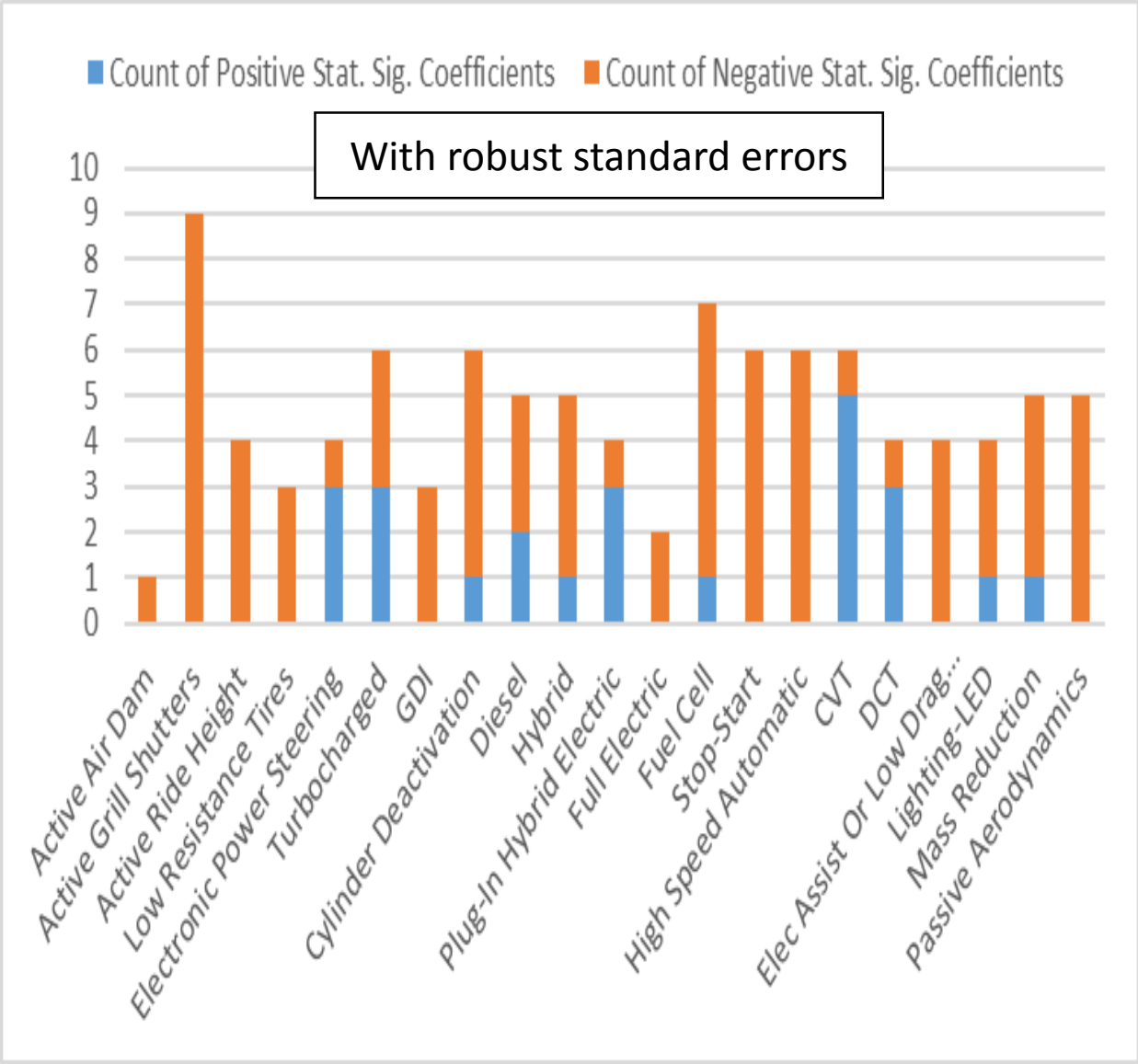
- The results of positive relationship are not very sensitive to standard errors
- Overall, the very small amount of statistically significant and positive relationship implies little evidence of hidden costs

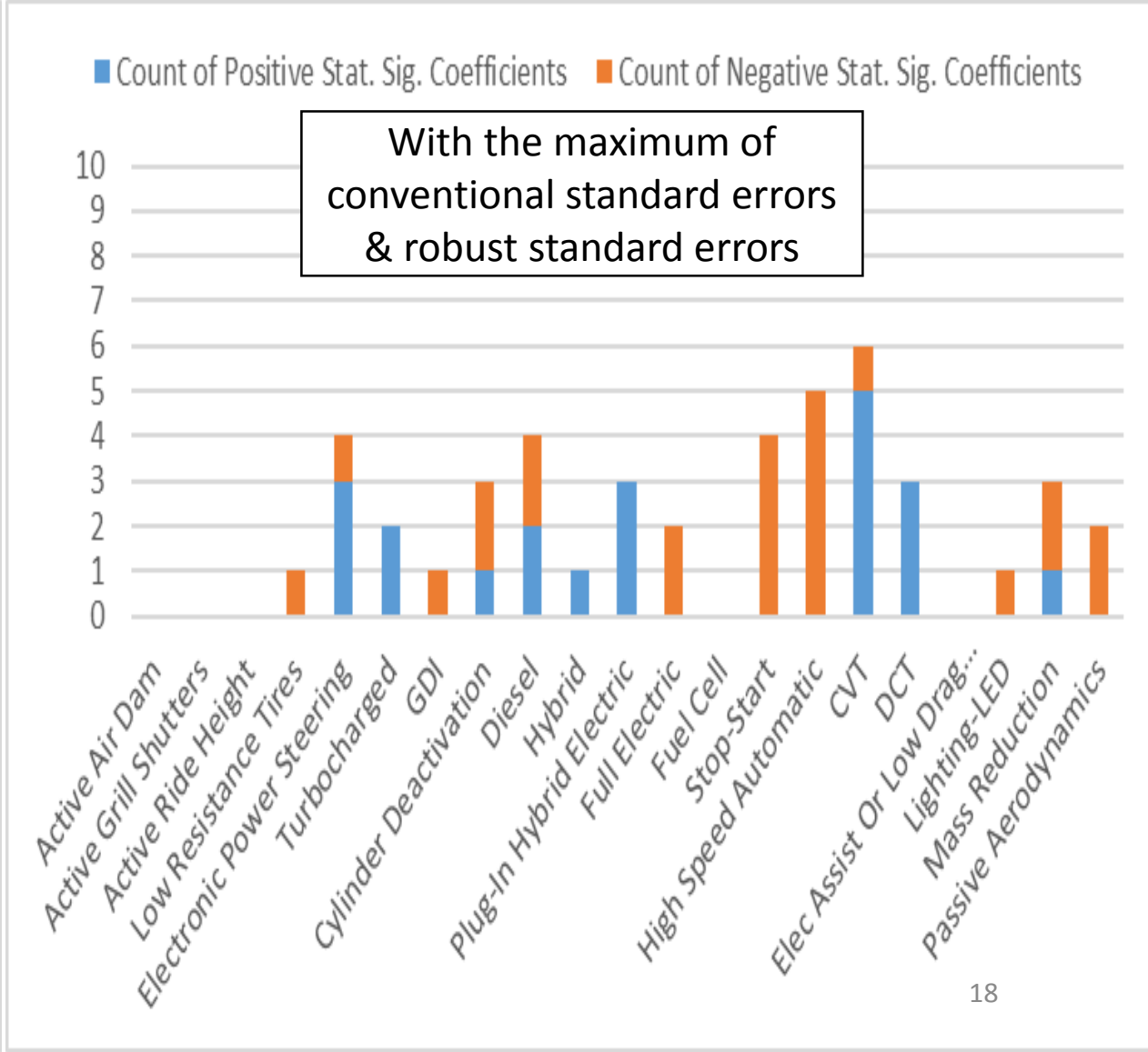
In testing differences between MY 2014 and MY 2015, only a small number of coefficients are statistically significant and positive



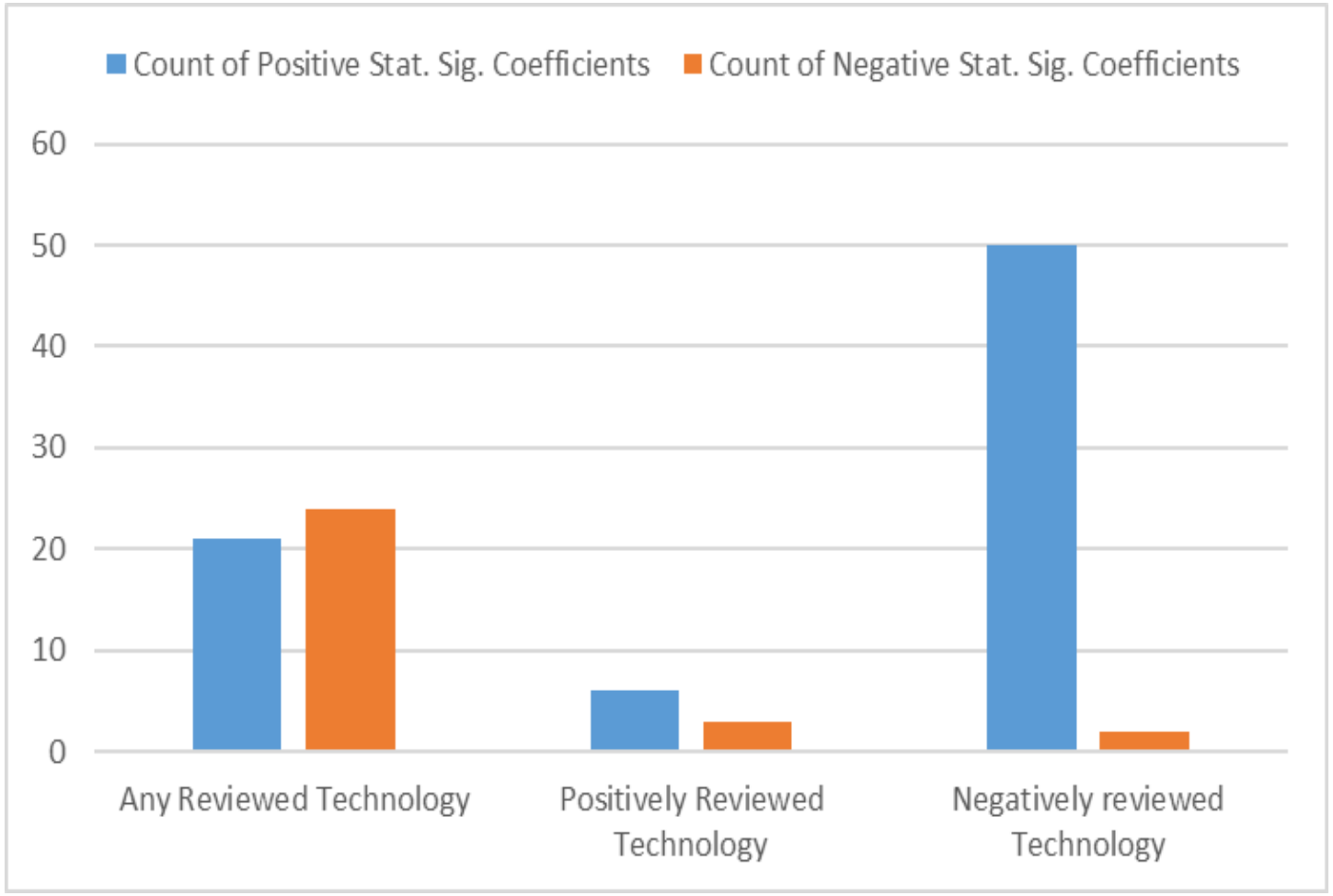
- Interaction terms between a technology and year are added to the regression models
- Out of a total of 462 possible coefficients, 6% or less are positive and significant
- The relationship of technologies and operational characteristics is similar over the two years

Out of 22 coefficients for each technology, there may be a few negatively evaluated technologies worth a deep dive. . .

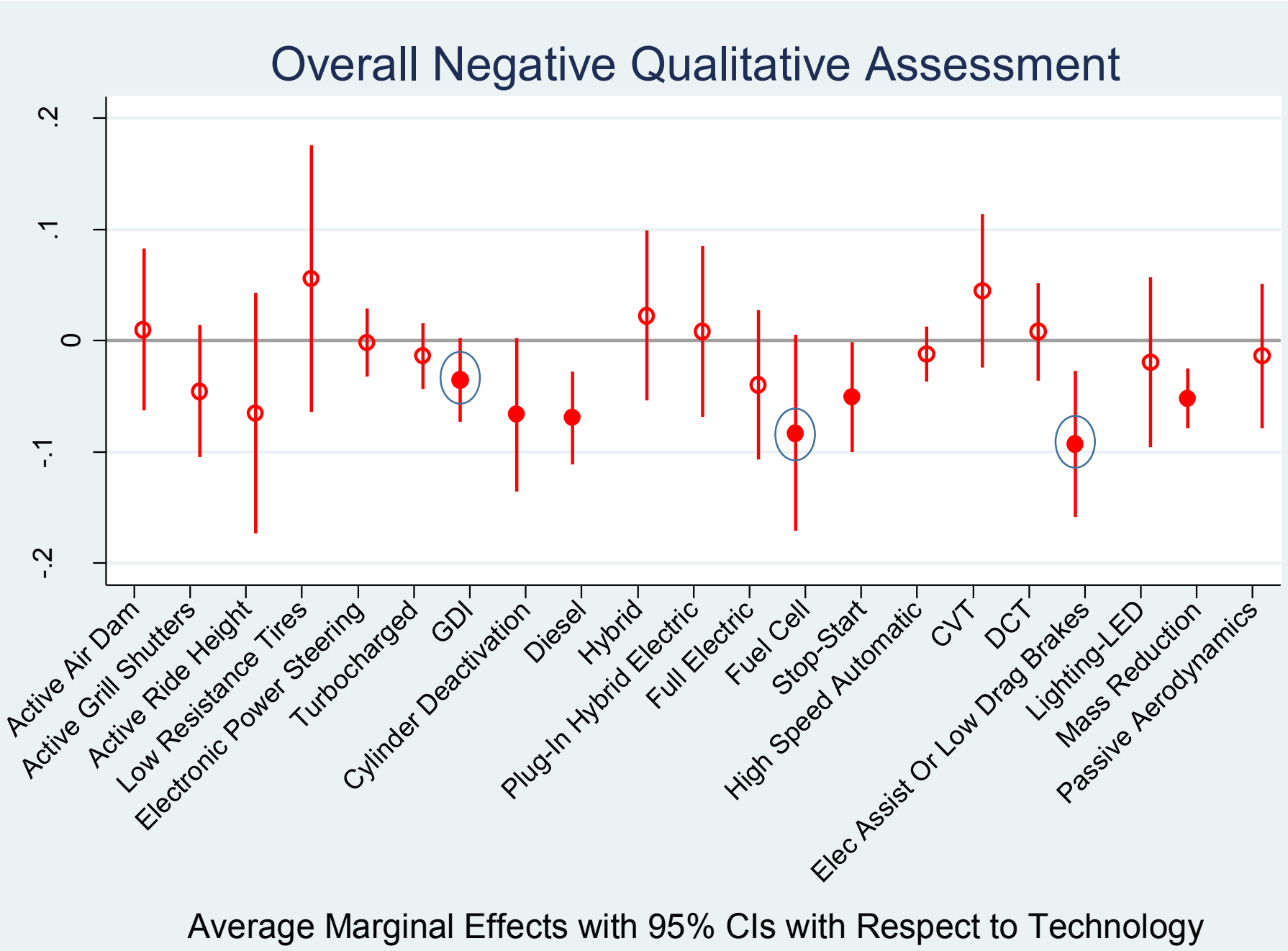




. . . But poor implementation may be a factor: Technologies that are negatively reviewed are more likely to be associated with negative evaluation



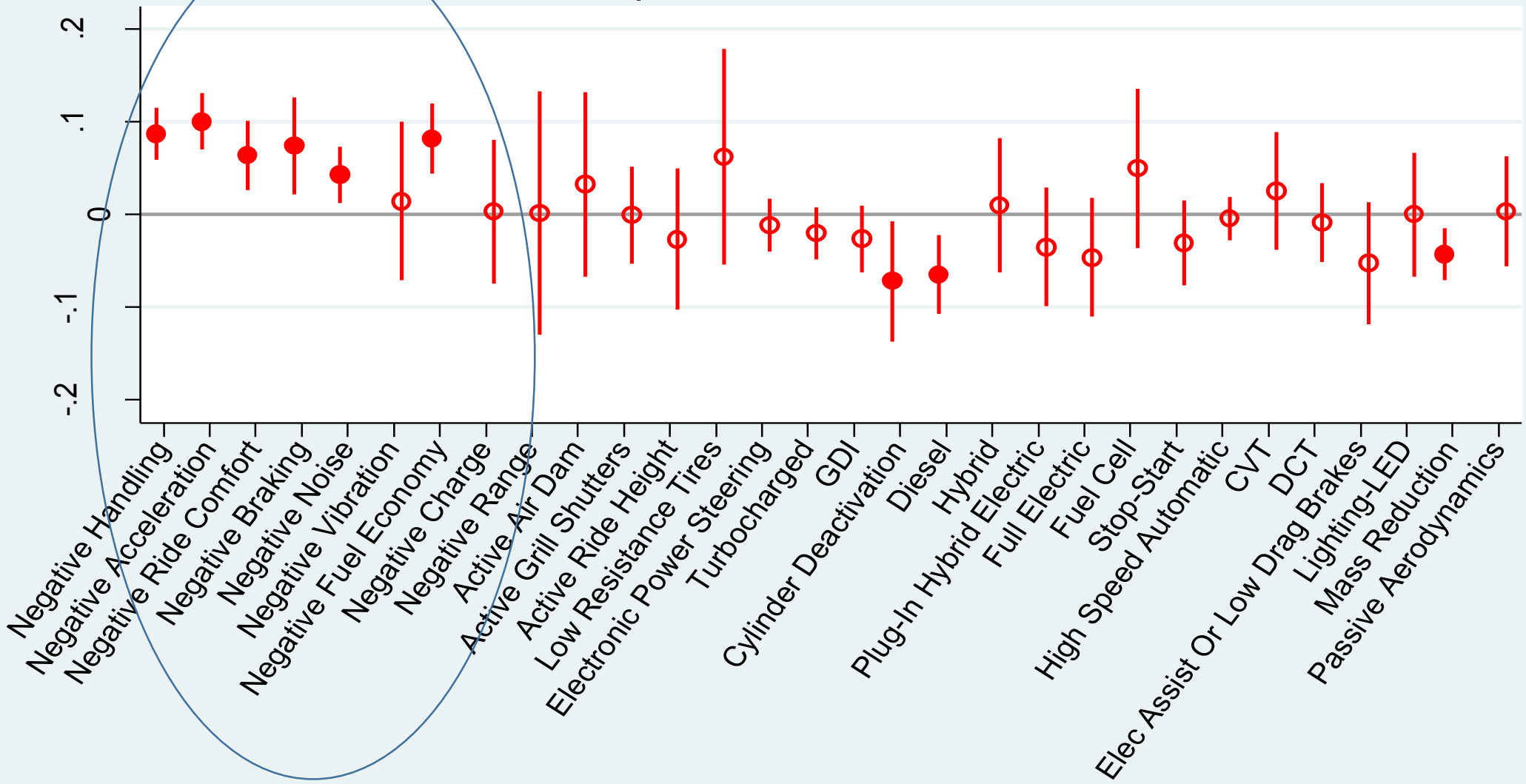
With the maximum of conventional standard errors & robust standard errors



- Dependent variable is overall negative qualitative assessment (buy or not to buy)
- The presence of some technologies (with solid marker) is related to <u>less</u> probability of getting overall negative review
- The blue circles become statistically insignificant using the maximum of robust & conventional standard errors

Overall Negative Qualitative Assessment

via Operational Characteristics



Average Marginal Effects with 95% CIs with Respect to Technology

Some limitations of this work

- We do not identify causal relationship
  - We cannot distinguish between technologies causing problems, or technologies being put into vehicles with problems
  - This is not a random sample of all new vehicles sold
- How reviewers evaluate vehicles may not correspond to how vehicle owners respond to the technologies
  - We suspect that auto reviewers are generally harder to please, and more likely to notice, than the general public
- The reviews will not capture longer-term issues, such as reliability or maintenance
  - These are new vehicles; those issues won't be known for some time

Automakers generally appear to have been able to implement technologies well

- Findings using MY 2015 data and pooled data are consistent with Helfand et al. (2016)
  - All technologies have positive/neutral reviews that substantially exceed negative reviews
  - Correlations between technologies and negative operational characteristics are more common when the technology is badly reviewed than just when the technology is present
  - If some implementations do worse than others, this is likely to be a temporary problem
- Hidden costs appear not to be an explanation of the energy paradox in light-duty vehicles
  - It seems possible to implement these technologies without harm to vehicle quality