

Information Saves Lives: An Impact Evaluation of Automobile Crash Tests

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Do Vehicle Crash Tests Save Lives?

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- Who cares?

Do Vehicle Crash Tests Save Lives?

- Who cares?
- Won't the market provide the optimal level of safety?

Where's the market failure?

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Where's the market failure?

- Won't the market provide the optimal level of safety?
- Theoretical reasons to be doubtful
 - Serious accidents are a rare event
 - The impact of safety features in the case of this rare event are probabilistic
 - So, the “benefit” of safety involves evaluating changes to small probabilities. Psychology / behavioral economics suggests people might not be good at this.
 - And does anyone know how rigid the safety cage is in their car? What a safety cage is? Whether their car has a collapsible steering column?

Where's the market failure?

- Won't the market provide the optimal level of safety?
- Empirical: If safety were optimal before, should see no market response to the test results.
 - (And because the tests use real resources, they would reduce efficiency.)

An example from the literature

THE EFFECT OF INFORMATION ON PRODUCT QUALITY: EVIDENCE FROM RESTAURANT HYGIENE GRADE CARDS*

GINGER ZHE JIN AND PHILLIP LESLIE

This study examines the effect of an increase in product quality information to consumers on firms' choices of product quality. In 1998 Los Angeles County introduced hygiene quality grade cards to be displayed in restaurant windows. We show that the grade cards cause (i) restaurant health inspection scores to increase, (ii) consumer demand to become sensitive to changes in restaurants' hygiene quality, and (iii) the number of foodborne illness hospitalizations to decrease. We also provide evidence that this improvement in health outcomes is not fully explained by consumers substituting from poor hygiene restaurants to good hygiene restaurants. These results imply that the grade cards cause restaurants to make hygiene quality improvements.

Research Questions

- Will testing vehicles for crashworthiness and providing the results to consumers lead to:
 - Automakers producing safer cars?
 - Consumers buying safer cars?
 - A reduction in accident fatalities?

Answers from this project

- Will testing vehicles for crashworthiness and providing the results to consumers lead to:
 - Automakers producing safer cars?
 - Consumers buying safer cars?
 - A reduction in accident fatalities?
- “Yes” to all 3 questions

Previous Literature on Improving Crashworthiness

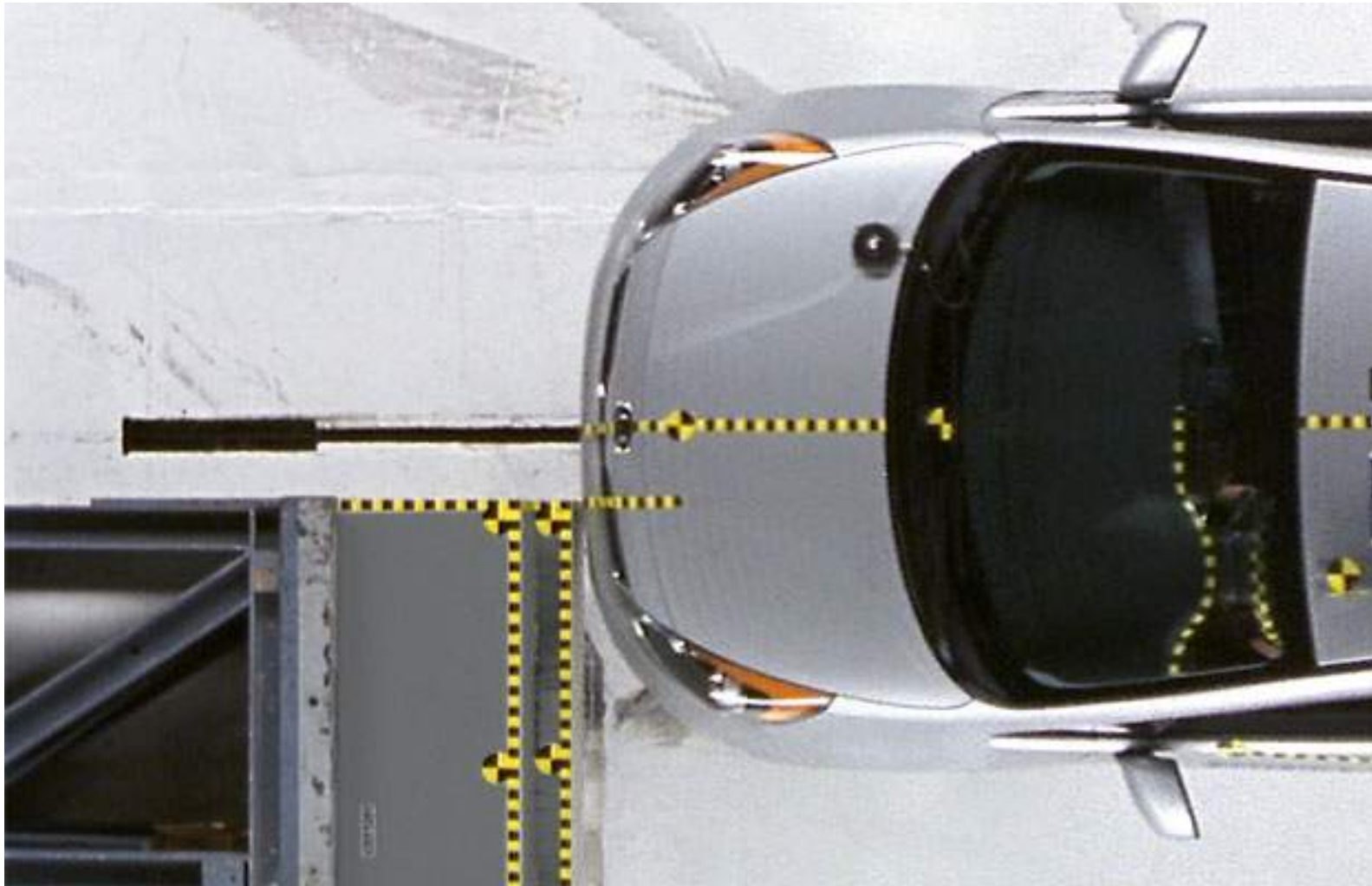
- There are many papers in the public health literature that investigate the degree to which newer cars are safer
- Many of these suffer from potential selection bias
- Most look at overall death rates rather than conditioning on potentially fatal accident occurring
- One particular problem: no other paper I have found uses year of vehicle redesign. Instead, they use model year or year of first registration.
 - A problem: Model year, year of accident, and vehicle age are colinear.
 - So, if there is driver selection by vehicle age and a time trend, how does one interpret coefficient on model year?

Program: IIHS Moderate Overlap

Front Crash Testing

- The Insurance Institute for Highway Safety began performing frontal crash tests of vehicles in the US in 1995
- IIHS scores vehicles as Good, Acceptable, Marginal, or Poor and publicizes results
- Automakers often use the results of these tests in their marketing materials
- NHTSA had been performing full-width frontal crash tests since the late 1970s.

IIHS Moderate Overlap Frontal Test



Car collides with 2 ft high deformable barrier at 40mph.

Photo source: IIHS

Structural Measures

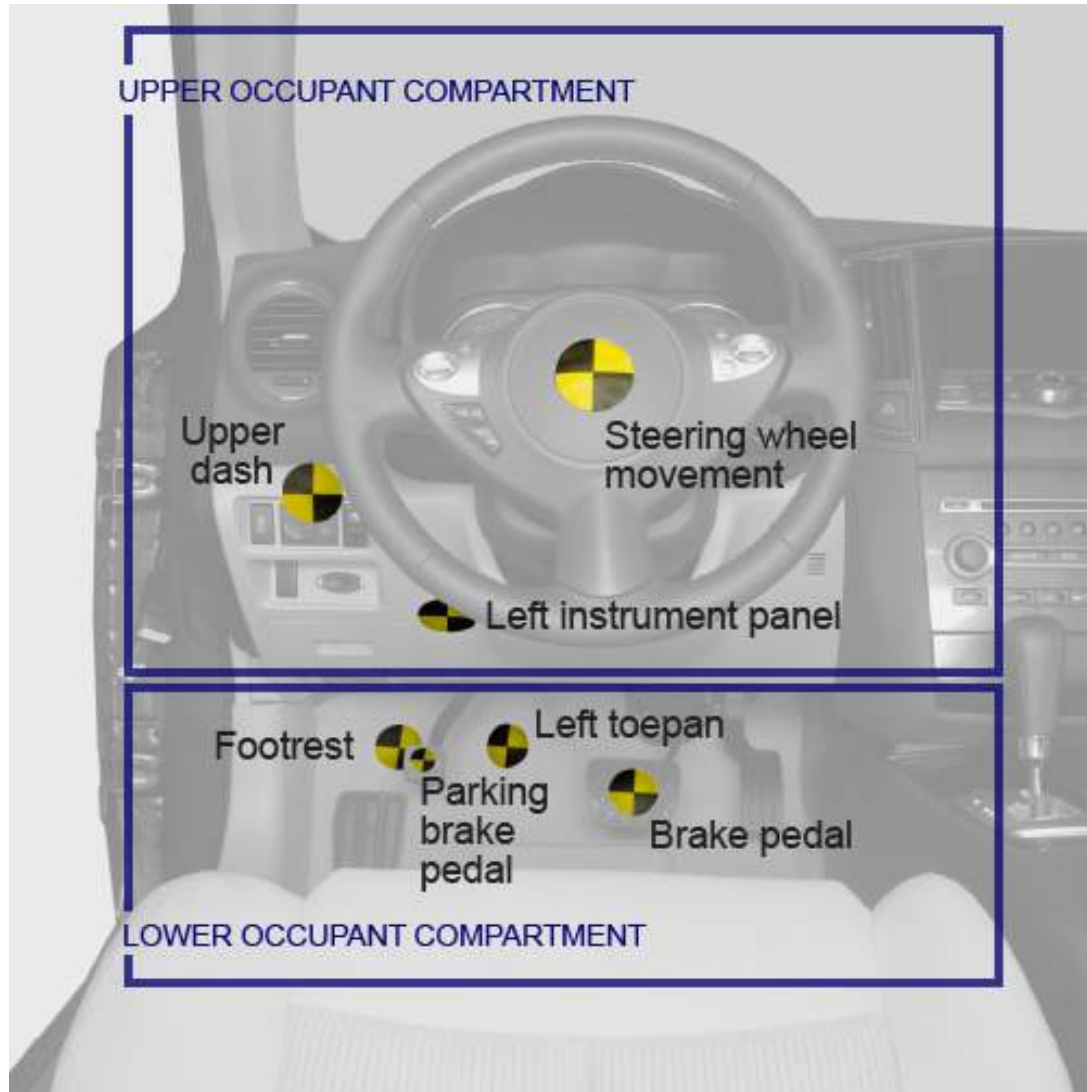


Photo source:
IIHS

IIHS Side Impact Test



Photo source:
IIHS

Automaker Response to Testing

- A response could be immediate if existing technology could be applied quickly
- A response could take time if new technology needed to be developed.
 - Driven by competition and R&D
- Responses can be made most easily / inexpensively during the process of vehicle redesign

Example: 2012 Camry v. 2013 Accord

- IIHS introduced another new crash test in 2012, the “Small Overlap Frontal Test”

2012 Camry



Applies to 2012-14 models

Overall evaluation	P
Structure and safety cage	P
Injury measures	
Head/neck	G
Chest	G
Hip/thigh	G
Lower leg/foot	A
Restraints and dummy kinematics	P






































2013 Accord



Applies to 2013-14 models

Overall evaluation	G
Structure and safety cage	A
Injury measures	
Head/neck	G
Chest	G
Hip/thigh	G
Lower leg/foot	G
Restraints and dummy kinematics	G

Toyota Camry IIHS Ratings

Model year	Front overlap		Side	Roof strength	Head restraints & seats	Front crash prevention
	Small	Moderate				
2001						
2000						
1999						
1998						
1997						
1996						
1995						
1994						


Redesign
year



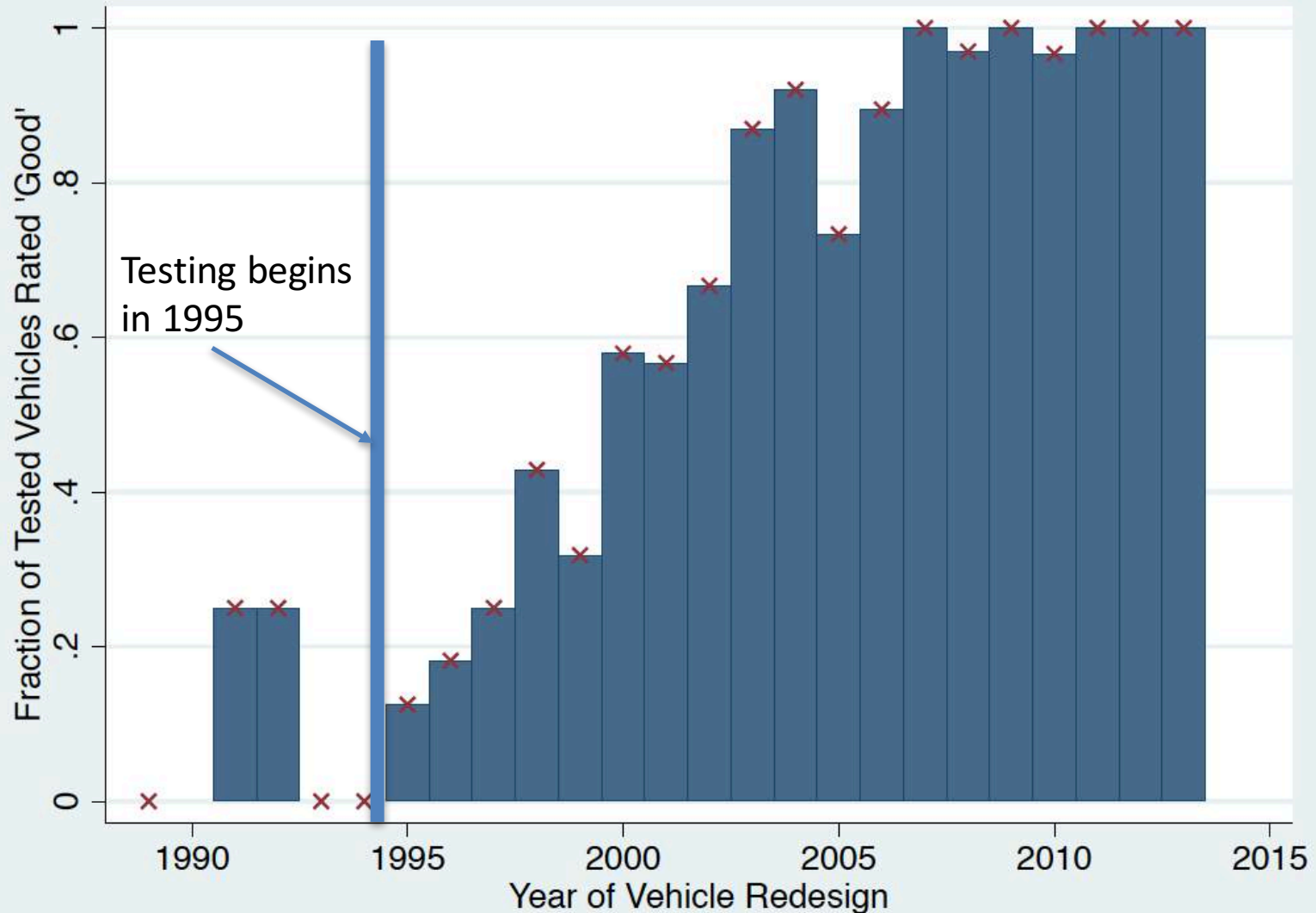
Toyota Camry IIHS Ratings

Model year	Front overlap		Side	Roof strength	Head restraints & seats	Front crash prevention
	Small	Moderate				
2008						
2007						
2006						
2005						Redesign year
2004						
2003						Redesign year
2002						
2001						

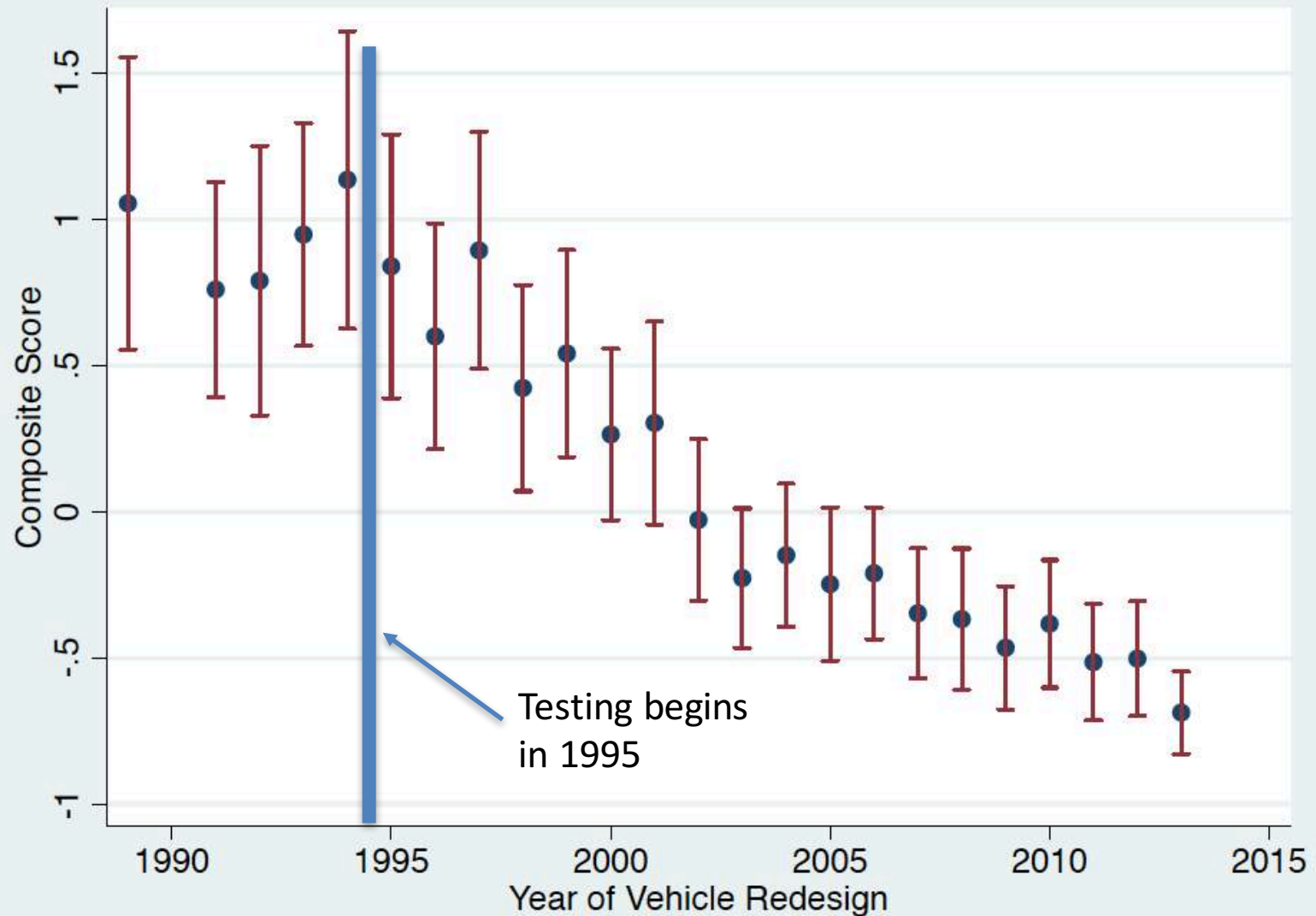
Toyota Camry IIHS Ratings

Model year	Front overlap		Side	Roof strength	Head restraints & seats	Front crash prevention
	Small	Moderate				
2017	G	G	G	G	G	 advanced
2016	G	G	G	G	G	 advanced
2015	G	G	G	G	G	 advanced
2014	A	G	G	G	G	 not available
2013	P	G	G	G	G	 not available
2012	P	G	G	G	G	
2011		G	G	G	M	 Redesign year

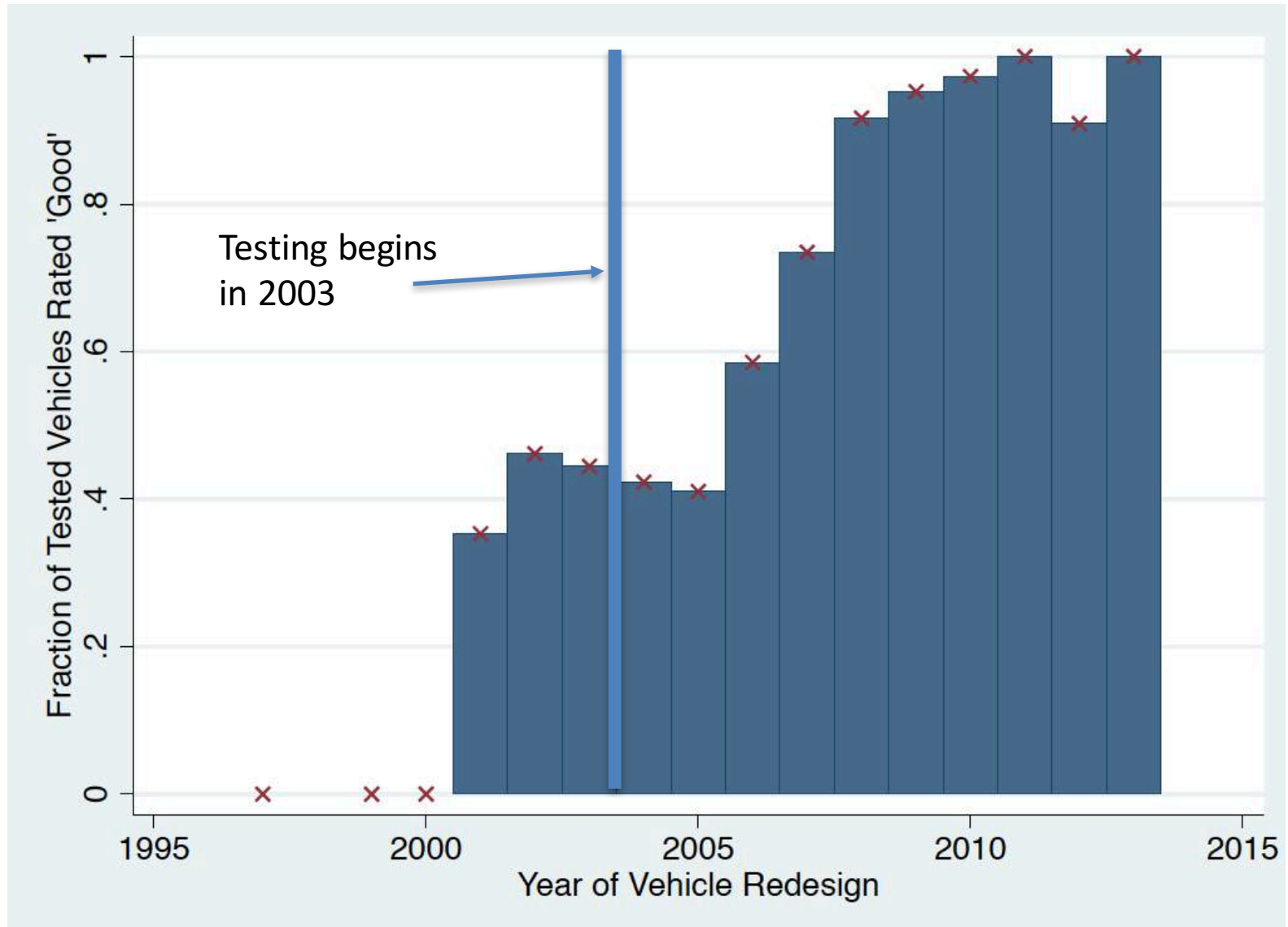
Automaker Response to Testing- Moderate Overlap Frontal Test



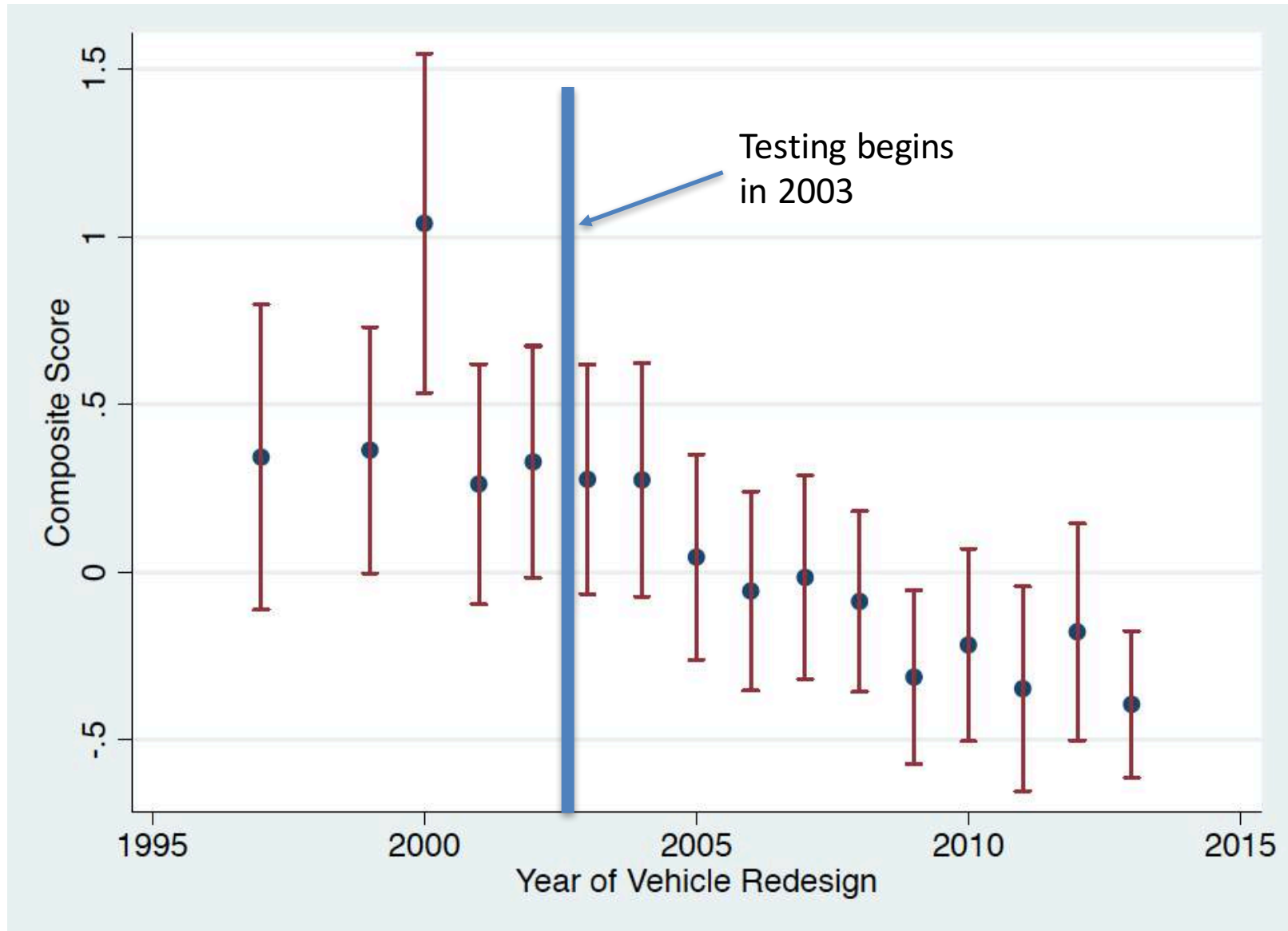
Automaker Response to Testing- Moderate Overlap Frontal Test



Automaker Response to Testing-Side Impact Test



Automaker Response to Testing-Side Impact Test



Consumer Response to IIHS Test Results

- Good crash test results / safety ratings (both NHTSA and IIHS) are routinely used in advertising by car manufacturers
- On Honda Accord's web page:



Consumer Response to IHS Test Results

Front Test Scores, 2001 NHTS

	Freq	Freq	log (Freq)	log (Freq)
Rating Change	7611*** (2361)	5529** (2360)	0.249*** (0.074)	0.179** (0.077)
Just Redesigned		22733*** (7420)		0.504*** (0.192)
R-squared	0.28	0.29	0.63	0.64
Observations	893	893	433	433

Consumer Response to IHS Test Results

	Side Test Scores, 2009 NHTS			
	Freq	Freq	log (Freq)	log (Freq)
Rating Change	3198** (1364)	1195 (1348)	0.235*** (0.073)	0.152** (0.069)
Just Redesigned		27063*** (3480)		0.906*** (0.114)
R-squared	0.19	0.23	0.60	0.63
Observations	2409	2409	1207	1207

Model of Impacts on Vehicle Safety

- Thought experiment:
 - 2 cars of known characteristics and with drivers crashed into one another (front to front)
 - Record whether each driver dies
 - Repeat many times, varying any characteristics of interest to find impact of those characteristics on probability of driver death
- IRB (and my conscience) would not approve this, so look for a natural experiment

Model of Impacts on Vehicle Safety

- Model developed in “Environmental Policy and Vehicle Safety: The Impact of Gasoline Taxes,” Econ Inq 2015
- Use FARS data: every fatal accident in US over decades
 - limit to accidents in which one of the drivers died
 - limit to accidents involving front-to-front or front-to-driver’s side collision
 - look at accidents in which only one driver died: can estimate the impact of vehicle/driver characteristics on **relative odds** of driver death with accident severity held constant (since two drivers in same accident)
 - look at frequency of accidents in which both drivers died: can normalize these relative risks to impacts on **probability** of driver death in the average “potentially fatal” accident

Model of Impacts on Vehicle Safety

- Label the two cars i, j
- Write the probability of driver death in each car as a function of own-car, other-car, and accident characteristics:

$$p_i = g(Z_i, Z_j, \mu_k)$$

$$p_j = g(Z_j, Z_i, \mu_k)$$

Model of Impacts on Vehicle Safety

- Each accident/observation falls into one of three categories with the given probabilities:

1. The type i car driver dies and the type j car driver does not die

$$\frac{p_i(1 - p_j)}{p_i + p_j - p_i p_j}$$

2. The type i car driver does not die and the type j car driver dies

$$\frac{(1 - p_i)p_j}{p_i + p_j - p_i p_j}$$

3. Both the type i car and the type j car drivers die

$$\frac{p_i p_j}{p_i + p_j - p_i p_j}$$

Estimating the Model

- The likelihood of observing any particular set of outcomes is a product of terms of the three types given above
- The parameters of the model can be estimated by maximum likelihood techniques
- Since taking log's is required and logs don't like negative numbers, a linear specification is embedded in a standard normal to represent probabilities:

$$p_i = \Phi(Z_i\alpha_i + Z_j\alpha_j + \mu_k\alpha_k)$$

- Coefficient estimates below are reported as marginal effects

	Vehicles Involved in Head-On Collision			Vehicles Struck on Driver's Side		
	Vehicles in which Driver Died	Vehicles in which Driver Survived	p-value for Difference	Vehicles in which Driver Died	Vehicles in which Driver Survived	p-value for Difference
Vehicle Characteristics						
Vehicle weight (pounds)	3576.2	4947.9	<0.0001	3273.4	5108.5	<0.0001
Vehicle Class						
% Sedan	68.4	36.6	<0.0001	80.7	38.2	<0.0001
% SUV	8.3	18.8	<0.0001	5.4	16.2	<0.0001
% Minivan	4.8	6.4	<0.0001	3.3	4.5	<0.01
% Pickup Truck	16.6	35.7	<0.0001	8.6	38.9	<0.0001
% Van	0.4	2.1	<0.0001	0.2	2	<0.0001
% Airbag Deployed	48.2	56.8	<0.0001	34.3	29.6	<0.001

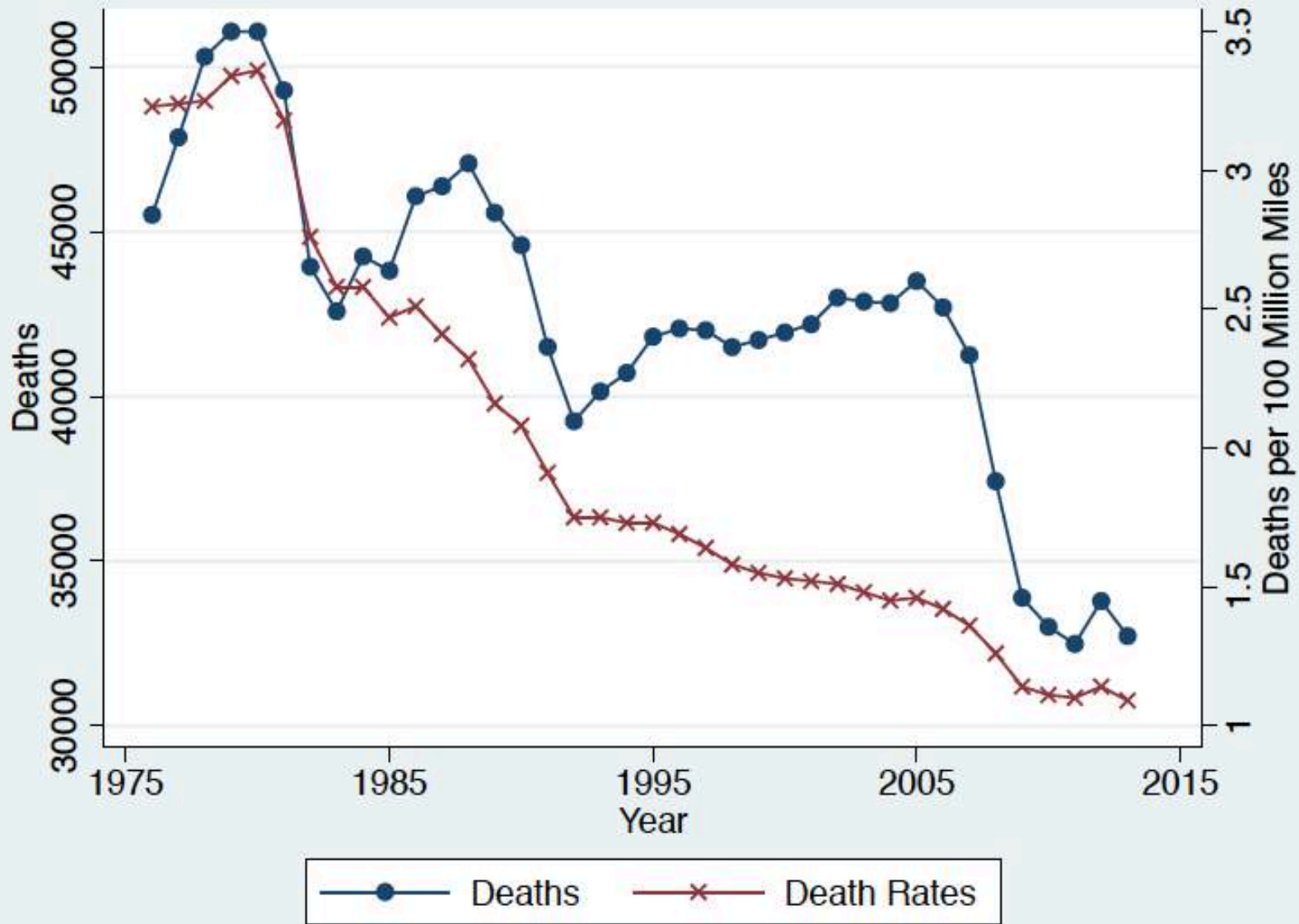
	Vehicles Involved in Head-On Collision			Vehicles Struck on Driver's Side		
	Vehicles in which Driver Died	Vehicles in which Driver Survived	p-value for Difference	Vehicles in which Driver Died	Vehicles in which Driver Survived	p-value for Difference
Driver Characteristics						
Mean Age	45.5	37.5	<0.0001	52.9	39	<0.0001
% Female	36.7	31.2	<0.0001	44.9	29.3	<0.0001
% Using Seatbelt	55.2	77.7	<0.0001	69.3	83.3	<0.0001
% Using Alcohol	21.7	13.0	<0.0001	10.9	5.7	<0.0001
Number of Observations	36,383	28,815		19,977	1,685	

Head-on Collisions:

Redesign year	-0.00252*** (0.000653)	-0.00144** (0.000724)	-0.00260*** (0.000676)	-0.00136* (0.000766)	-0.000893 (0.000804)
Redyr >=1995		-0.0207*** (0.00609)		-0.0211*** (0.00625)	-0.0161** (0.00680)
Redyr>=2003			0.00343 (0.00749)	-0.00233 (0.00768)	0.0118 (0.0107)
Redyr * Redyr>=1995					-0.00249* (0.00130)
Model year	-0.00640*** (0.000737)	-0.00638*** (0.000737)	-0.00642*** (0.000739)	-0.00636*** (0.000739)	-0.00626*** (0.000741)

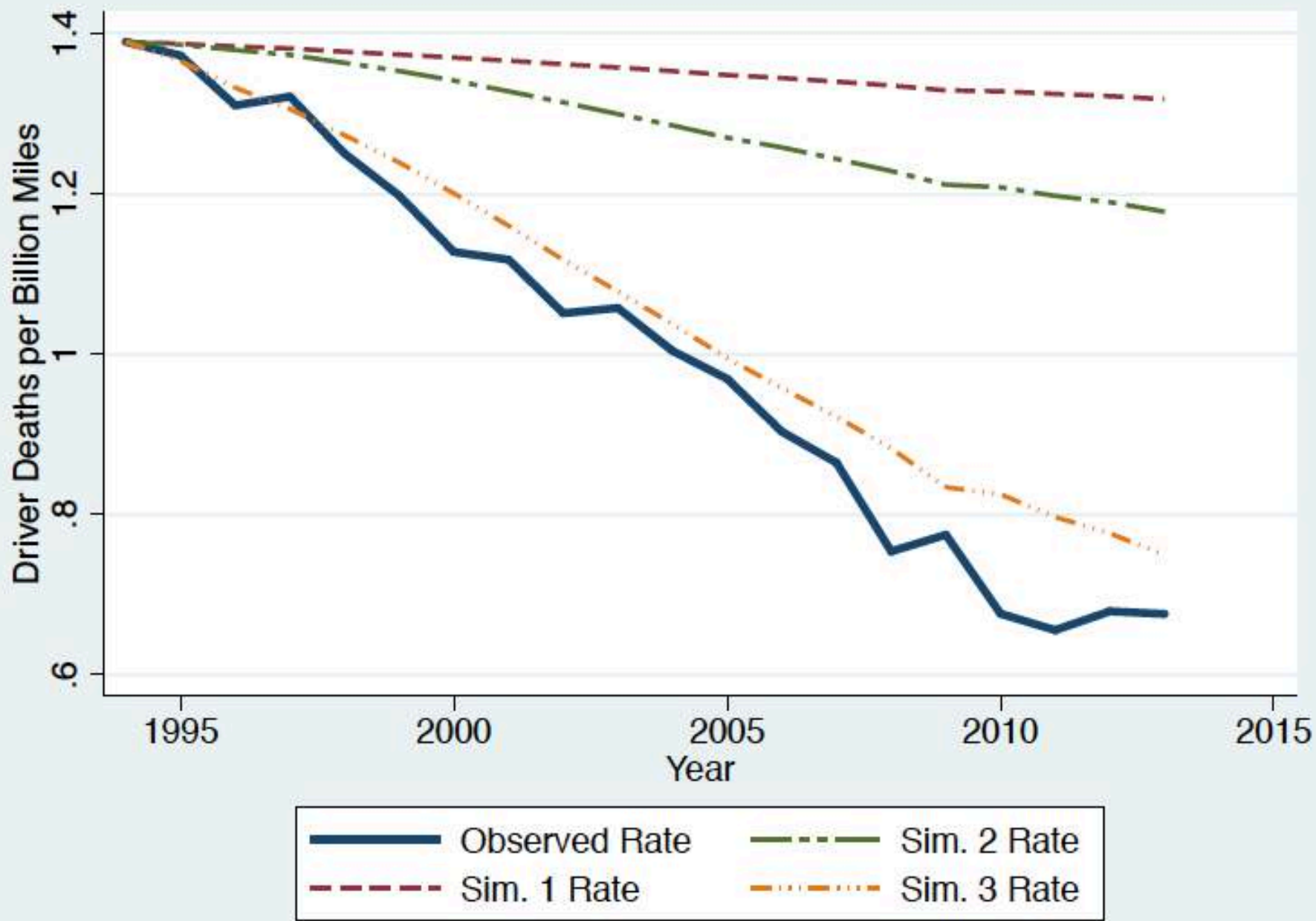
Side Impact Collisions:

Redesign year	0.00533*** (0.00193)	0.00614*** (0.00202)	-0.00372* (0.00199)	-0.00449** (0.00210)	-0.00439** (0.00211)
Redyr >=1995		0.0246* (0.0149)		0.0207 (0.0152)	0.0200 (0.0154)
Redyr>=2003			-0.0632*** (0.0216)	-0.0587*** (0.0220)	-0.0262 (0.0361)
Redyr * Redyr>=2003					-0.0105 (0.00885)
Model year	-0.00436** (0.00219)	-0.00446** (0.00220)	-0.00420* (0.00219)	-0.00429* (0.00219)	-0.00415* (0.00220)

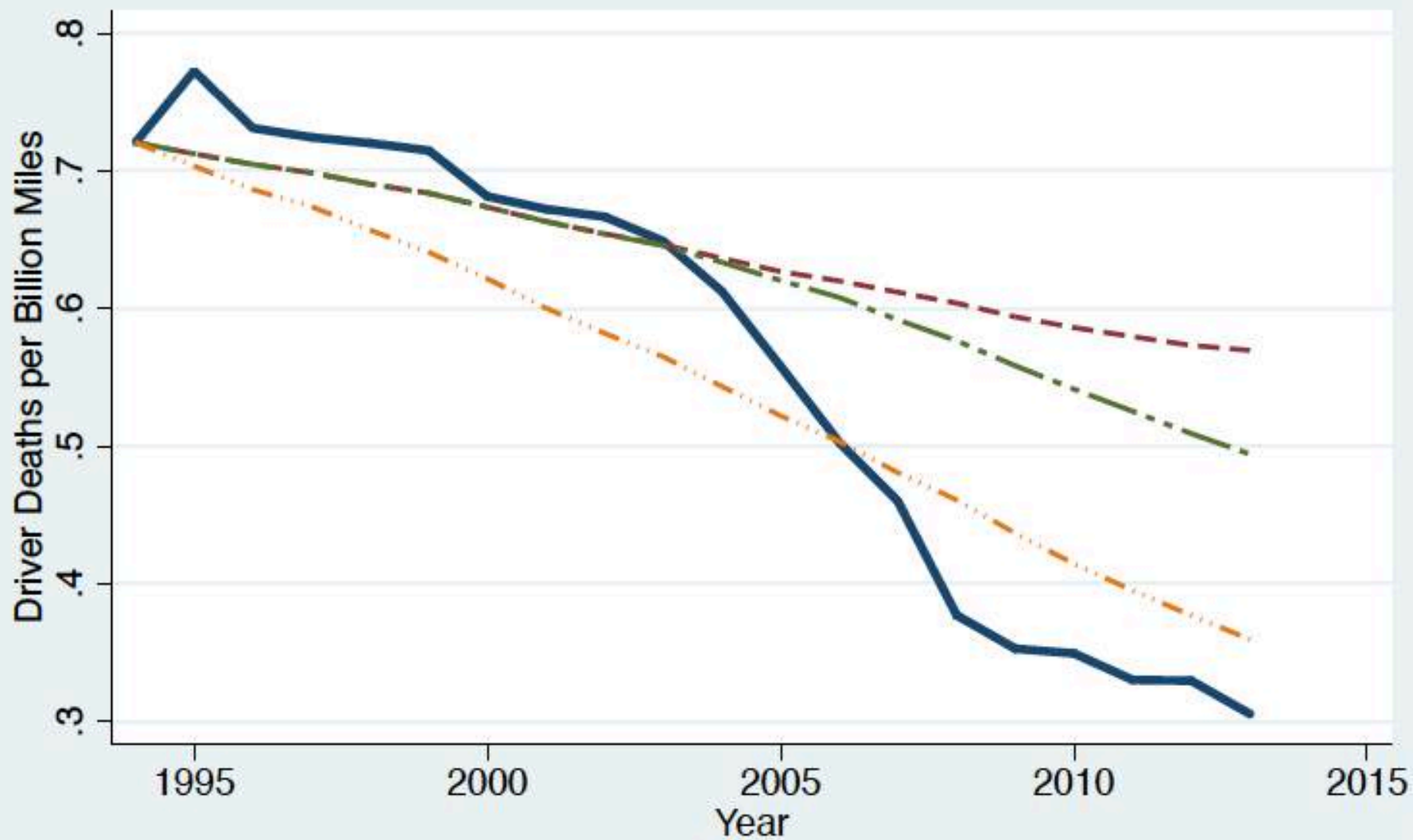


Source: Data available from the Insurance Institute for Highway Safety on their website.

(a) Driver Deaths in Head-on Collisions



(b) Driver Deaths in Side-Impact Collisions



Prevented Fatalities

- Simulation 2 results predict 1,800 fewer fatalities in 2013 than would have occurred in the absence of the crash test programs
- This is an underestimate (given the model results) because it assumes no benefits in crashes other than 2-car head-on or front-to-side

Economic Benefit of Increased Safety

- Using \$9.1 million per VSL, the prevented fatalities would be valued roughly \$820 per vehicle
- What about prevented injuries?
 - 70 times as many injuries as fatalities
 - Mean injury “worth” 10% of the VSL used (lots of underlying research and assumptions here)
 - Further assuming 1 AIS reduction in injury yields total value of prevented injuries valued at roughly 4.4 times that of prevented fatalities.
- Total value of prevented injuries and fatalities would then be on the order of \$3,600 per vehicle

Final Thoughts

- Costs are hard to quantify here, but seem unlikely to exceed the \$3,600 per vehicle benefit (or even half that)
 - This is more than 10% the cost of the average vehicle
 - Mainstream vehicles (e.g. Camry, Accord) have increased in price at less than the rate of inflation since the mid-90s
- These programs seem exceedingly likely to have benefits that exceed costs
- Information failures were imposing efficiency costs in markets for vehicles
- Interestingly, in this case, there was at least a partial “market” solution in that IIHS is a private organization.
 - (Partial because government crash tests and regulations have also been important here. Required airbags stand out as an important example of the latter.)