The Global Impact of Environmental Regulation through Multinational Firms

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A country's regulation often affects multinational firms

- Examples:
  - Environmental regulations on cars, electric appliances, etc.
  - Safety regulations on equipment, medications, etc.

- A country's domestic policy may affect people living in other countries
  - A country's policy affects the product design of multinational firms
  - If the product is sold worldwide, the policy impact may spillover

- However, economic analysis usually does not incorporate this possibility
  - e.g. Analyses of environmental policies usually focus on domestic benefits
  - Conventional analysis may have understated the impact of many policies

I investigate this question in the international car markets

- Automakers often sell common models in many countries
  - The world best selling models (Toyota Carolla, Rav4, Honda Civic, CR-V etc.) are sold in many countries
  - A country's environmental policy might affect the design of these models
  - If the product is sold worldwide, the policy impact may spillover

Related literature?

- My RAs could not find existing papers directly related to this question
- I have not yet asked ChatGPT
- Any related literature?

Policy: JPN government's subsidy for fuel-efficient vehicles

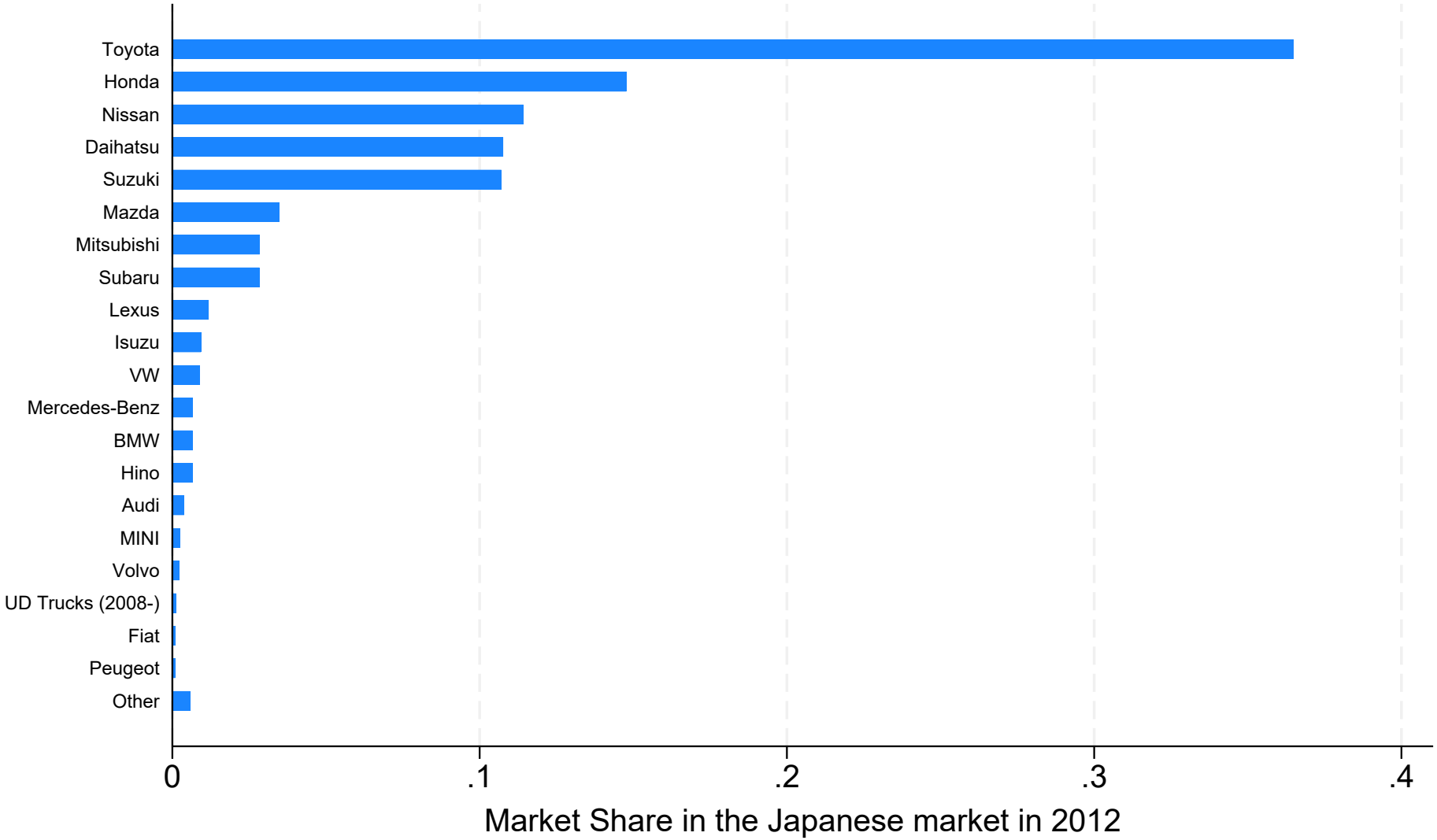
- "Eco-car" subsidy started in April, 2009
  - Consumers received a $1,000 subsidy for a new car purchase if the model exceeds its 2015 fuel economy target
  - A stronger incentive for automakers to improve each model's fuel economy than the CAFE b/c the incentive was at the model level
  - Firms responded to it by improving fuel economy

- However, it was considered to be an "expensive" policy
  - The government spent $6.3 billion for the subsidy

Hypothesis: did the policy generate international spillovers?

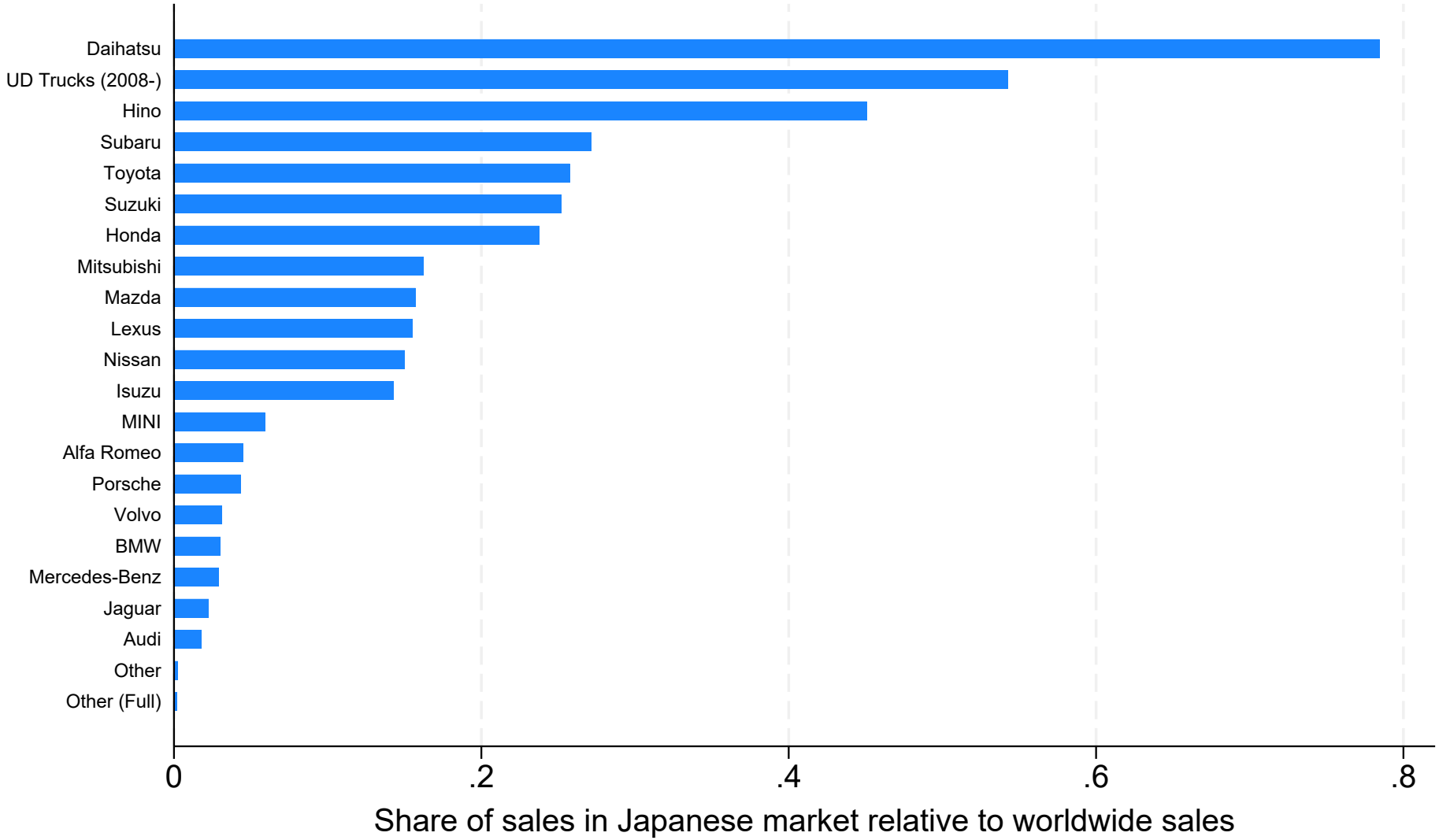
- What could be important factors for the potential spillover effect?
  - Firms face fixed costs of changing each model's product design
  - The subsidy incentive needs to be large enough to cover the fixed cost
- Conditions for home country:
  - The market has to be big enough for the model, otherwise it makes little sense for firms to respond to the subsidy's incentive
- Conditions for spillovered country:
  - Spillover impact is economically significant if the model's market share in the spillovered country is also larger

Which firms sell the most in the Japanese market?



- JPN firms dominate, European firms are second, and almost no American cars

Market share in Japan relative to a firm's worldwide sales



- JPN market is important for JPN & European firms, not so for American firms

Identification strategy and data

- Identification strategy
  - Want to estimate JPN policy's impact on MPG of cars sold outside JPN
  - We use the difference-in-differences (DID) method
  - Time: before and after the policy introduction
  - Treated: models sold in home county (JPN) and spillovered country (US)
  - Control: the same firms' models sold in the US but NOT sold in JPN

- Data
  - Car characteristics data and sales data at the model level
  - Data sources: web-scraped car characteristics, sales from Marklines
  - Currently collected data for Japan, US, Germany, India
  - Linking models between countries is not obvious and needs careful work

Difference-in-differences for cars sold by JPN automakers

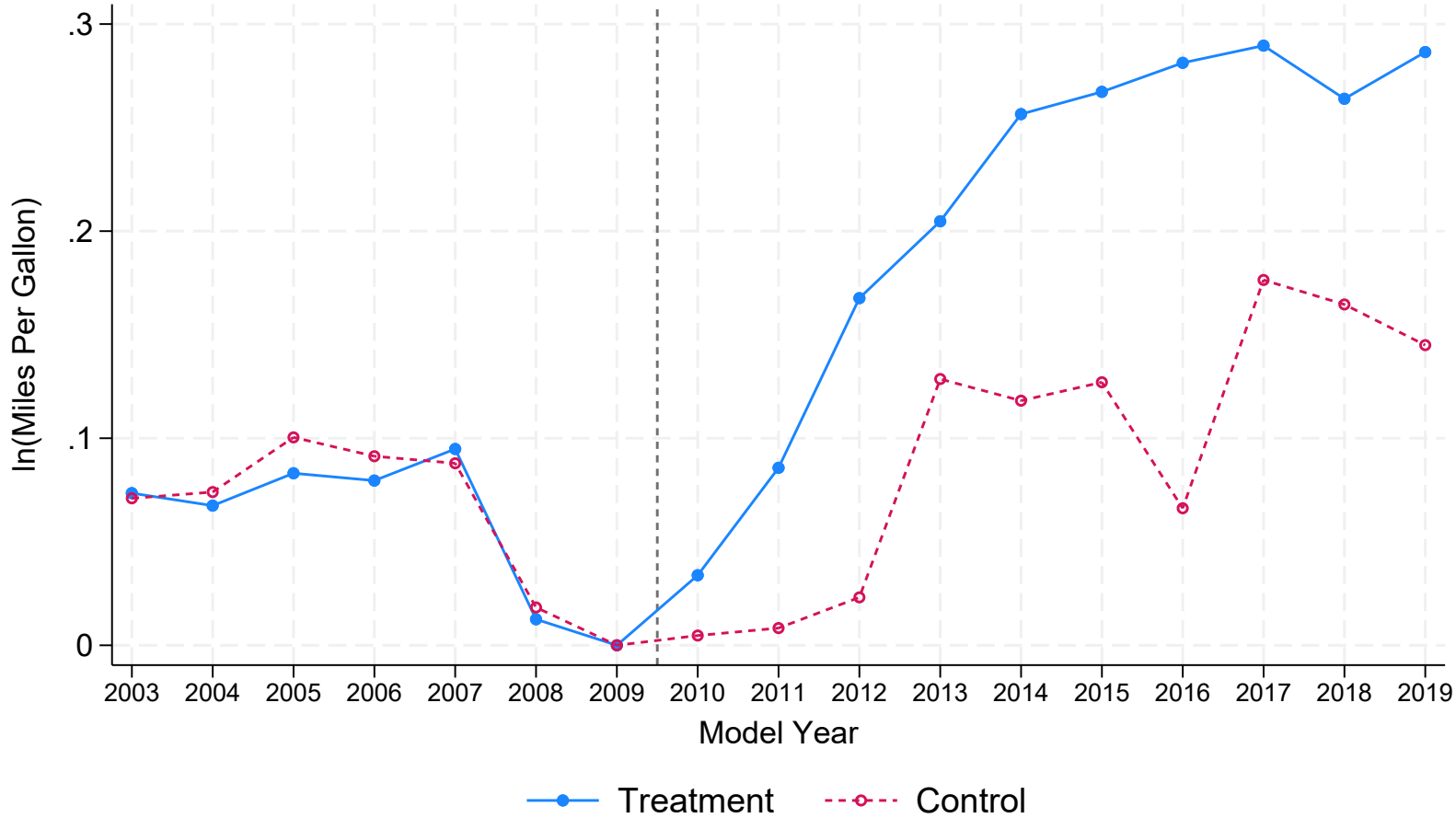
$$\ln MPG_{it} = \alpha Treated_i \times Post_t + \beta Treated_i + \gamma Post_t + \delta X_{it} + \epsilon_{it}$$

- Variables:
  - MPG_{it} is miles per gallon for vehicle i and model year t in the US market
  - $Treated_i = 1$ if model i is also sold in Japan
  - $Post_t = 1$ after the introduction of the fuel-efficiency subsidy in Japan
  - X_{it} is a set of control variables (e.g, model and time fixed effects)
  - Standard errors clustered at the model level to adjust for serial correlation
- Identification assumption:
  - Parallel trend of MPG between 1) models sold in both countries and 2) models not sold in Japan

Japanese cars in the US market

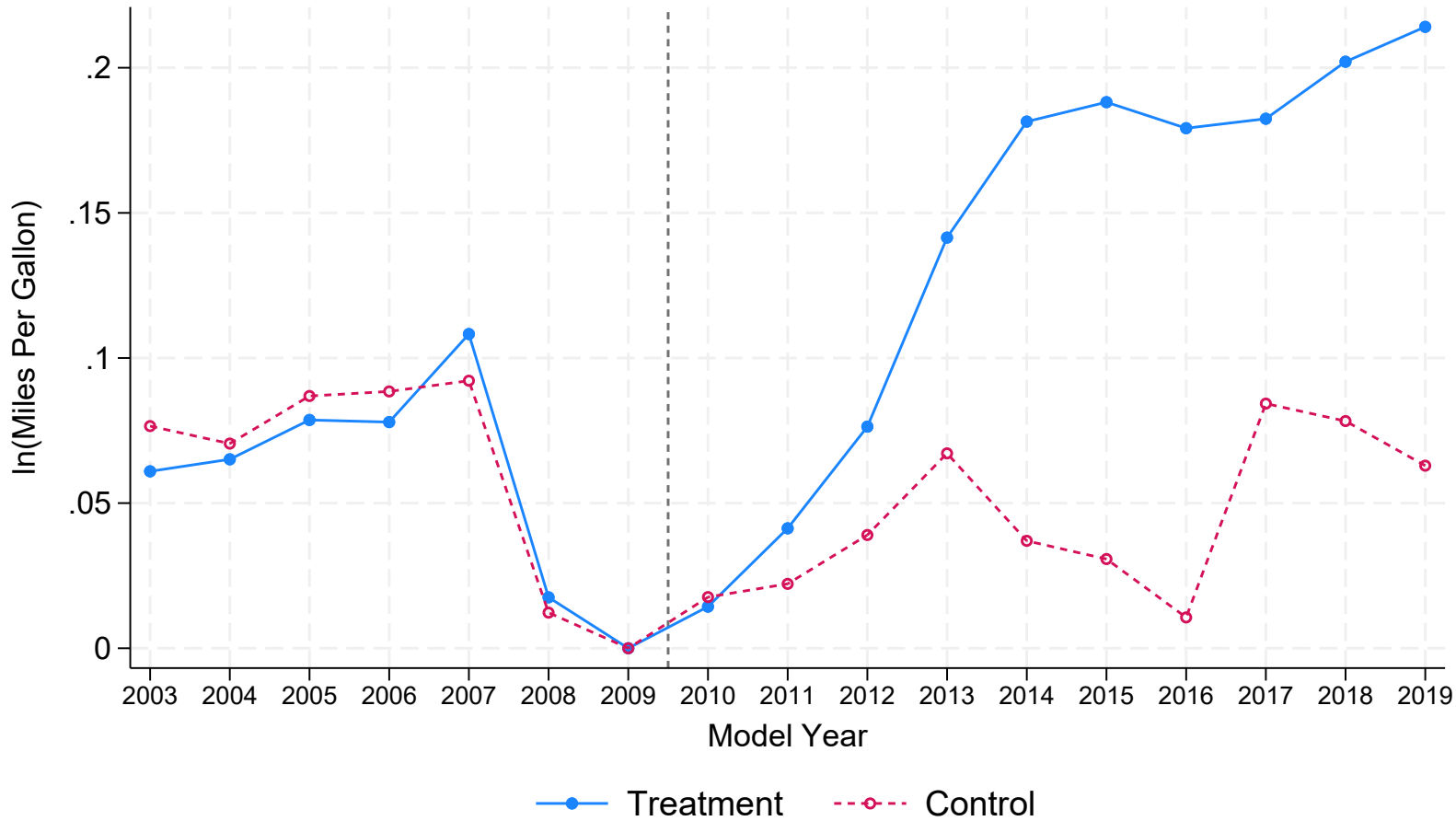
- US is the top 2 country in car sales (18.5% of the world sales)
- Japanese automakers have a 36.5% market share in the US

Average ln(MPG) in the US market: Unweighted



- Treatment: Japanese cars sold in the US and Japan (90 models)
- Control: Japanese cars sold in the US but not in Japan (41 models)
- Vertical line: Introduction of the fuel-efficiency subsidy in Japan

Average ln(MPG) in the US market: Weighted by sales



- Treatment: Japanese cars sold in the US and Japan (90 models)
- Control: Japanese cars sold in the US but not in Japan (41 models)
- Vertical line: Introduction of the fuel-efficiency subsidy in Japan

Spillover effects for Japanese cars in the US market

$$\ln MPG_{it} = \alpha Treated_i \times Post_t + \beta Treated_i + \gamma Post_t + \delta X_{it} + \epsilon_{it}$$

	(1)	(2)	(3)	(4)
Treated × Post	0.112	0.108	0.085	0.080
	(0.042)	(0.041)	(0.025)	(0.025)
Treated	0.298	0.299		
	(0.062)	(0.062)		
Post	-0.007		0.007	
	(0.037)		(0.016)	
N	1,178	1,178	1,176	1,176
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Spillover effects: 8∼11% increase in fuel economy

American cars in the US market

- American automakers have a 45.1% market share in the US.
- American automakers have a 0.2% market share in Japan.

Spillover effects for American cars in the US market

$$\ln MPG_{it} = \alpha Treated_i \times Post_t + \beta Treated_i + \gamma Post_t + \delta X_{it} + \epsilon_{it}$$

	(1)	(2)	(3)	(4)
Treated × Post	0.040	0.040	-0.019	-0.018
	(0.049)	(0.048)	(0.031)	(0.031)
Treated	-0.102	-0.102		
	(0.062)	(0.062)		
Post	0.093		0.093	
	(0.033)		(0.023)	
N	1,329	1,329	1,325	1,325
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Treatment: US cars sold in the US and Japan (59 models)
- Control: US cars sold in the US but not in Japan (144 models)
- Insignificant effects → could makes sense b/c of the low market share in Japan

Japanese cars in the German market

- Germany is the top 5 country in car sales (3.9% of the world sales)
- Japanese automakers have a 9.8% market share in Germany

Spillover effects for Japanese cars in the German market

$$\ln MPG_{it} = \alpha Treated_i \times Post_t + \beta Treated_i + \gamma Post_t + \delta X_{it} + \epsilon_{it}$$

	(1)	(2)	(3)	(4)
Treated × Post	0.083	0.076	0.078	0.076
	(0.035)	(0.031)	(0.024)	(0.020)
Treated	-0.263	-0.263		
	(0.114)	(0.115)		
Post	0.061		0.047	
	(0.022)		(0.014)	
N	547	547	543	543
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Treatment: Japanese cars sold in Germany and Japan (84 models)
- Control: Japanese cars sold in Germany but not in Japan (7 models)
- Spillover effects: 8% increase in fuel economy

Japanese cars in the Indian market

- India is the top 4 country in car sales (4.6% of the world sales)
- Japanese automakers have a 49.2% market share in India

Spillover effects for Japanese cars in the Indian market

$$\ln MPG_{it} = \alpha Treated_i \times Post_t + \beta Treated_i + \gamma Post_t + \delta X_{it} + \epsilon_{it}$$

	(1)	(2)	(3)	(4)
Treated × Post	0.173	0.144	0.285	0.272
	(0.135)	(0.142)	(0.056)	(0.060)
Treated	-0.016	-0.016		
	(0.139)	(0.143)		
Post	0.115		-0.006	
	(0.123)		(0.009)	
N	147	147	145	145
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Treatment: Japanese cars sold in India and Japan (29 models)
- Control: Japanese cars sold in the India but not in Japan (13 models)

Welfare implications

Welfare implications of the international spillover effects

- Full welfare components
  - Consumer surplus may change (due to access to better MPG cars)
  - Producer surplus may change (due to changes in market competition)
  - Negative externalities may change (due to less gasoline usage)

- Today, I focus on the externality, with simplifying assumptions
  - No demand response—the MPG improvement does not change demand for these models & miles driven
  - Externality cost of gasoline is \$2.1 per gallon (EPA)
  - Focus on the effects on JPN models only (understate the effects)

Back of envelop calculation: Avoided negative externality

- What is the avoided negative externality in the US?
  - The subsidy in Japan resulted in a 8-11% improvement in MPG in JPN cars also sold in the US (this is ATT)
  - Using MPG and sales data for the treated models, calculate Δgallons
- Preliminary results for the US:
  - Δgallons saved $=$ 261 million per year in the US market
  - Δexternality reduced $=$ \$548 million pear year in the US market (using externality cost \$2.1 per gallon)

Back of envelop calculation: Avoided negative externality

- Preliminary results for Germany:
  - Δgallons saved = 7 million per year in the German market
  - Δexternality reduced = \$14.7 million pear year in the German market (using externality cost \$2.1 per gallon)

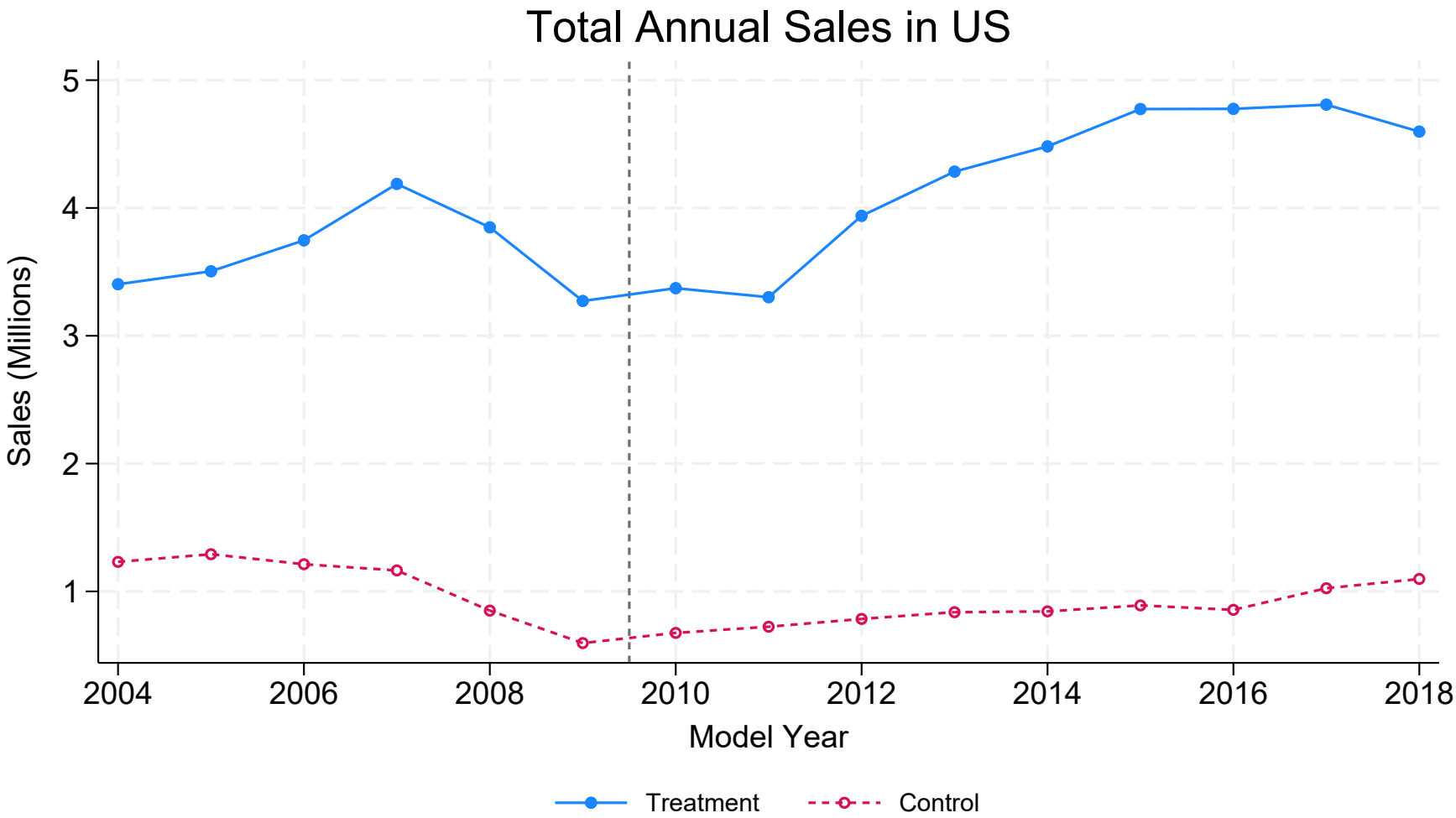
- Preliminary results for India:
  - Δgallons saved = 60.6 million per year in the Indian market
  - Δexternality reduced = \$127.3 million pear year in the Indian market (using externality cost \$2.1 per gallon)

Next steps

1. Include more countries?
   - Data access/quality can be challenging for some countries, but possible
2. Investigate more about mechanisms?
   - e.g. How does firms' production network affect the spillover
3. Full welfare analysis with a structural model?
   - Consumer surplus may change (due to access to better MPG cars)
   - Producer surplus may change (due to changes in market competition)
   - Negative externalities may change (due to less gasoline usage)

Appendix

Sales over time



- Electricity is a major source of GHG emissions (e.g., 25% in the US)
- Another large source is transportation, which can be electrified soon

JPN cars in Germany market (Control: US)

	(1)	(2)	(3)	(4)
Treated × Post	0.147	0.112	0.115	0.081
	(0.046)	(0.040)	(0.025)	(0.023)
Treated	0.595	0.628	-0.106	-0.080
	(0.062)	(0.056)	(0.022)	(0.020)
Post	-0.003		0.010	
	(0.037)		(0.017)	
N	793	793	790	790
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Treatment: Japanese cars sold in Germany and Japan (84 models)
- Control: Japanese cars sold in the US but not in Japan (41 models)

JPN cars in India market (Control: US)

	(1)	(2)	(3)	(4)
Treated × Post	0.382	0.365	0.319	0.286
	(0.050)	(0.050)	(0.035)	(0.031)
Treated	0.481	0.491	-0.107	-0.042
	(0.066)	(0.069)	(0.028)	(0.029)
Post	-0.016		0.010	
	(0.036)		(0.017)	
N	424	424	423	423
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Treatment: Japanese cars sold in India and Japan (29 models)
- Control: Japanese cars sold in the US but not in Japan (41 models)

European cars in the US market

- European automakers have a 8.5% market share in the US.
- European automakers have a 4.6% market share in Japan.

Spillover effects for European cars in the US market

$$\ln MPG_{it} = \alpha Treated_i \times Post_t + \beta Treated_i + \gamma Post_t + \delta X_{it} + \epsilon_{it}$$

	(1)	(2)	(3)	(4)
Treated × Post	0.069	0.072	0.108	0.095
	(0.049)	(0.052)	(0.016)	(0.022)
Treated	-0.151	-0.153		
	(0.075)	(0.074)		
Post	0.055		0.009	
	(0.045)		(0.012)	
N	962	962	959	959
Year FE	No	Yes	No	Yes
Model FE	No	No	Yes	Yes

- Treatment: EU cars sold in the US and Japan (95 models)
- Control: EU cars sold in the US but not in Japan (43 models)