

Innovation, Emissions Policy, and Competitive Advantage in the Diffusion of European Diesel Automobiles

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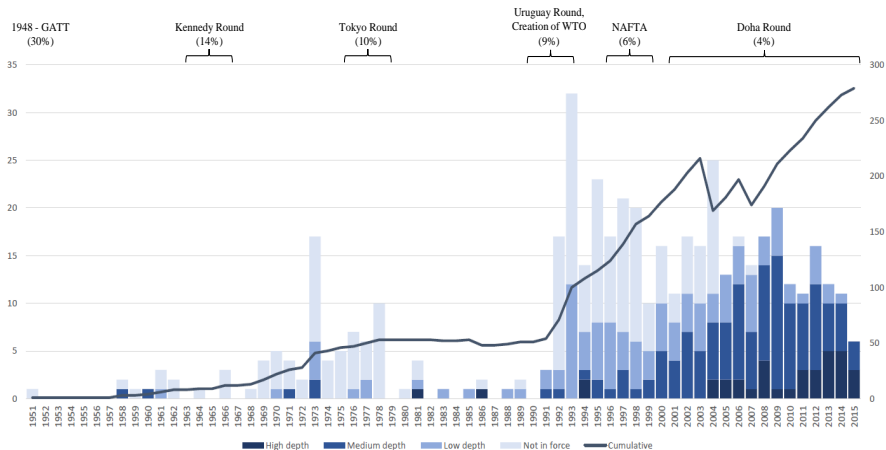
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Motivation: Significant Growth in Preferential Trade Agreements and Decline in Tariffs



Source: World Bank, WTO World Trade Report (2008)

Research Question

- 1 Are non-tariff policies effective tools to protect domestic industry now that import tariffs have been negotiated to zero?

Our Setting: Diesel Adoption in Europe

Hypothesis

EU emissions policy protected domestic automakers by promoting their competitive advantage: fuel-efficient, high-torque diesel vehicles.

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- ▶ Driving is expensive in Europe due to high fuel taxes.
- ▶ Diesels are popular in Europe.
 - VW introduces the TDI in 1989.
 - Technology quickly imitated rival EU automakers **but not foreign firms**.
 - Cars become very popular among consumers ($\sim 50\%$ of vehicles).

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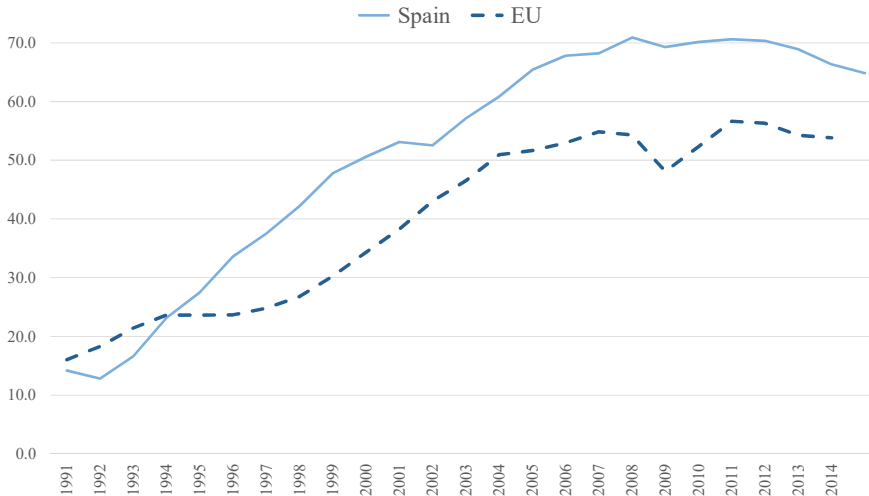
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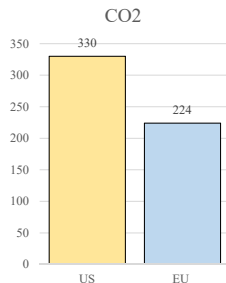
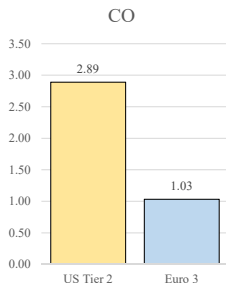
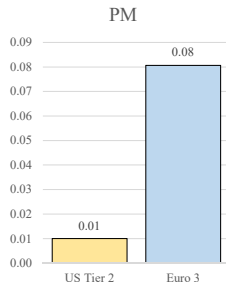
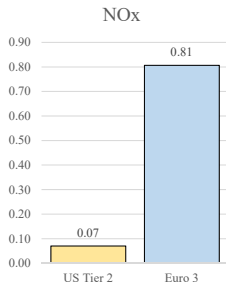
- ▶ Driving is expensive in Europe due to high fuel taxes.
- ▶ Diesels are popular in Europe.
 - VW introduces the TDI in 1989.
 - Technology quickly imitated rival EU automakers **but not foreign firms**.
 - Cars become very popular among consumers ($\sim 50\%$ of vehicles).
- ▶ At the same time EU regulators introduce new emissions regulations.
 - Standards favor diesels over fuel-efficient gasoline imports.

Data

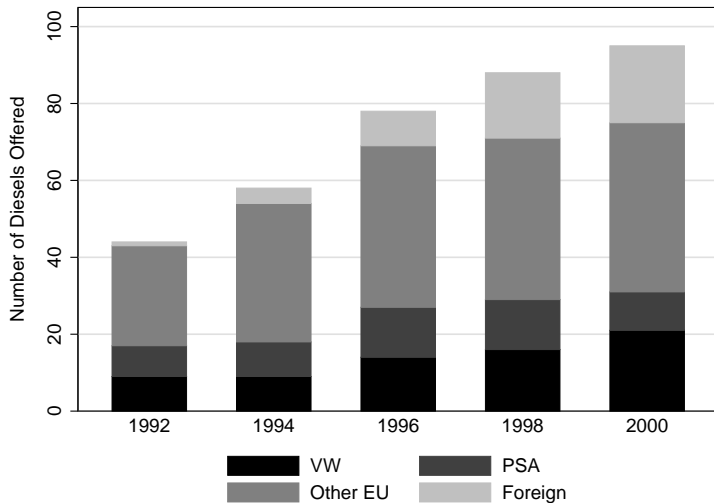
Diesel Adoption in Europe



A Non-Tariff Policy: EU vs US Emissions Policy (g/mi)



Who Produces Diesels? European Automakers.



Approach

Empirical Approach

- 1 Estimate consumer demand and automaker production costs using car registration data from Spain (1992-2000).
- 2 Use the estimated model as a laboratory to see how European automakers and consumers respond to more rigorous NO_x standards.
 - Diesel production costs \uparrow to *abate* NO_x emissions.
 - Allow automakers and consumers to reoptimize.

\Rightarrow Imports of gasoline cars \uparrow .
- 3 Solve for the import tariff which drives import share to the level we observe in the data.
 - *Import tariff equivalence.*

Results

Diesels are Valuable to Domestic Automakers

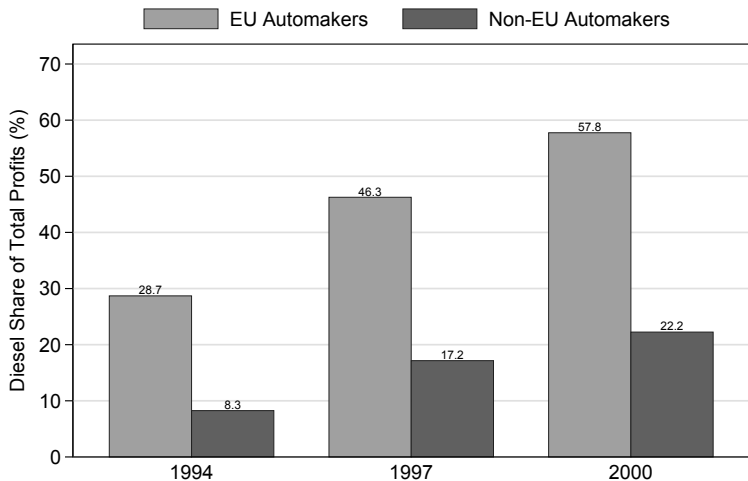
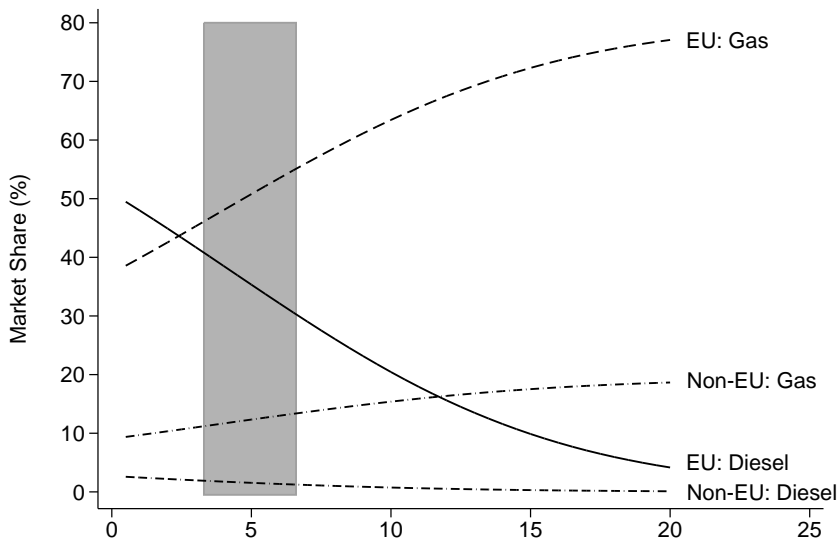


Figure: Share of Profits from Diesels

Did EU emissions policy protect domestic industry?

- ▶ Idea: Replace pro-diesel EU policy with US policy.
- ▶ How? Incorporate retrofitting costs into MC and resolve pricing equilibrium.
- ▶ Use EPA 2010 estimates to identify likely values.
- ▶ Hold product characteristics fixed.
⇒ Conclusions are short-run.

Modifying Diesel Engines to Meet Standards



Environmental Policy as Strategic Trade Policy

Question: What's the tariff-equivalence of diesels?

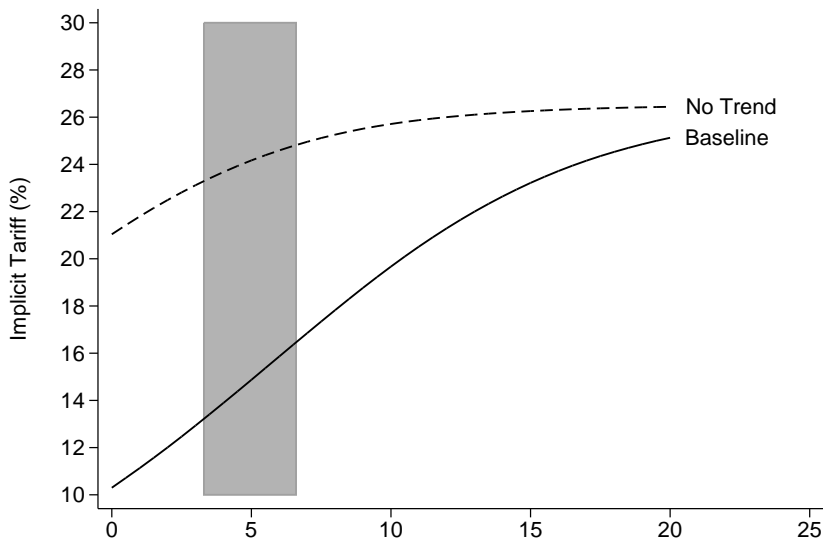
Idea:

1. Remove diesels and solve for equilibrium prices.
2. Solve for import tariff to generate the Non-EU market share observed under current EU emissions policy.

Results:

- In 1992, a 18.1% tariff achieves the observed import share (actual was 14.4%)
- In 2000, a 26.5% tariff achieves the observed import share (actual was 10.3%)

Environmental Policy as Strategic Trade Policy



Conclusion

Can a non-tariff policy be an effective tools to protect domestic industry?

Yes! We show the emissions policy employed by the EU promoted an innovation that non-EU firms were not interested in producing competitively.

→ Equivalent to a **13 – 16%** import tariff.

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Other Questions:

- 1 Impact to consumers?
- 2 Is this an example of a successful non-tariff strategic trade policy or just a fortunate accident?
- 3 What are the long-run implications?

Appendix

Diesels are Popular in the EU Market

- ▶ Diesel cars were a niche product in the 1980s.
- ▶ In 1989, VW introduced the TDI diesel engine.
 - 40 to 60% more fuel efficient (km/€) than gasoline engines.
 - Greater torque than gasoline engines.
 - Quiet and reliable with no smell.
- ▶ Other European automakers quickly imitated the technology but Foreign firms did not.

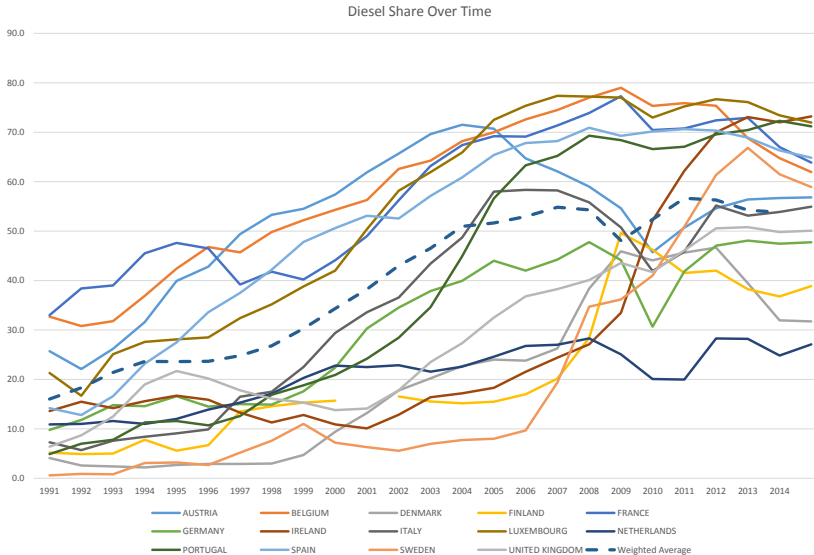
Diesels are Popular in the EU Market

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 - 40 to 60% more fuel efficient (km/€) than gasoline engines.
 - Greater torque than gasoline engines.
 - Quiet and reliable with no smell.
- ▶ Other European automakers quickly imitated the technology but Foreign firms did not.
- ▶ Diesels became a popular engine choice in Europe:
 - 10% of new car sales in 1990.
 - 50% of new car sales in 2000.

U.S. Emissions Policy Makes Diesels Unprofitable

- ▶ Early 1990s, US and EU passed key environmental regulations.
 - US regulators targeted NO_x emissions.
- ▶ Diesels produce a lot of NO_x but little CO and CO₂.
- ▶ VW and Mercedes pull diesel models from US market after implementation.

Diffusion of Diesels in Europe



Several Mergers

Table 3: Automobile Groups: 1992 vs. 2000

Automaker	Year 1992			Year 2000		
	Gasoline	Diesel	Owner	Gasoline	Diesel	Owner
ALFA ROMEO	5,038	64	ALFA ROMEO	2,941	3,983	FIAT
AUDI	16,689	1,982	VW	15,273	24,184	VW
BMW	17,855	1,906	BMW	13,683	15,838	BMW
CHRYSLER	1,243	–		5,941	2,389	
CITROËN	68,890	36,851	PSA	46,420	111,694	PSA
DAEWOO	–	–		25,201	–	
FIAT	35,677	5,733	FIAT	30,557	17,967	FIAT
FORD	121,140	17,468	FORD	55,268	57,013	FORD
HONDA	4,805	–		8,782	1,072	
HYUNDAI	2,704	–		30,150	3,590	
KIA	–	–		9,778	1,387	
LANCIA	11,117	905	LANCIA	2,206	2,126	FIAT
MAZDA	3,064	–		2,205	1,480	
MERCEDES	9,352	4,129	MERCEDES	13,953	10,684	MERCEDES
MINI	3,041	–		3,660	1,013	
NISSAN	16,010	905		17,855	21,971	
OPEL	110,286	11,099	GM	66,488	75,418	GM
PEUGEOT	61,323	35,494	PSA	55,371	92,496	PSA
RENAULT	147,907	27,448	RENAULT	76,925	99,360	RENAULT
ROVER	15,255	425	ROVER	10,173	8,491	ROVER
SAAB	1,551	–	SAAB	1,867	2,424	GM
SEAT	85,773	11,787	VW	58,072	109,447	VW
SKODA	724	–	SKODA	5,003	10,385	VW
SUZUKI	2,058	–		3,250	486	
TOYOTA	4,425	–		16,827	3,584	
VOLKSWAGEN	50,561	5,471	VW	47,125	50,296	VW
VOLVO	10,179	–	VOLVO	7,379	3,566	FORD

Automobile Characteristics by Segment

Table 1: Car Model Characteristics by Origin and Engine Types

YEAR/GROUP	MODELS	SHARE	PRICE	C90	KPE	SIZE	HPW
1992							
EU: DIESEL	43	16.60	12.26	4.45	46.42	73.84	31.43
EU: GASOLINE	73	79.45	11.05	5.39	29.62	71.50	41.22
NON-EU: DIESEL	1	0.09	13.76	5.30	38.58	80.51	28.61
NON-EU: GASOLINE	24	3.86	14.88	5.82	27.31	77.99	45.27
ALL	141	100.0	11.40	5.25	32.33	72.15	39.74
2000							
EU: DIESEL	75	50.95	16.19	4.55	38.18	76.32	31.43
EU: GASOLINE	84	37.28	14.93	5.68	24.23	73.40	38.98
NON-EU: DIESEL	20	2.71	17.20	5.41	32.63	82.48	32.15
NON-EU: GASOLINE	50	9.06	13.66	6.11	22.80	75.32	40.85
ALL	229	100.0	15.52	5.13	31.43	75.31	35.12

◀ Return

Automobile Characteristics

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1992							
EU: DIESEL	43	16.60	12.26	4.45	46.42	73.84	3.14
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NON-EU: DIESEL	1	0.09	13.76	5.30	38.58	80.51	2.86
NON-EU: GASOLINE	24	3.86	14.88	5.82	27.31	77.99	4.53
ALL	141	100.00	11.40	5.25	32.33	72.15	3.97
2000							
EU: DIESEL	75	50.95	16.19	4.55	38.18	76.32	3.14
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NON-EU: GASOLINE	50	9.06	13.66	6.11	22.80	75.32	4.08
ALL	229	100.00	15.52	5.13	31.43	75.31	3.51

Changing Automobile Characteristics

- ▶ More car models.
- ▶ Cars are bigger, less powerful, less fuel efficient, and more expensive.

Table: Changing Car Characteristics - Intensive Margin

Year	Models		Percent Changed		
	New	Old	C90	$\frac{HP}{Weight}$	Car Size
1992	14	127	7.87	14.17	3.15
1993	22	132	31.82	32.58	7.58
1994	22	145	39.31	47.59	11.72
1995	27	160	28.75	31.87	7.50
1996	29	173	27.17	31.79	12.14
1997	25	185	38.38	47.03	13.51
1998	30	193	31.09	36.27	11.40
1999	24	203	36.95	37.44	8.37
2000	18	211	36.49	39.81	10.90

Increasingly Stringent Emission Policies

Table 5: Value of Diesels to Different Regions

	Products		Price		Share		Markup		Profit	
	Base	CF	Base	CF	Base	CF	Base	CF	Base	CF
1992										
EU: DIESEL	43	0	12.3	-	16.6	-	15.0	-	281.2	-
EU: GASOLINE	73	73	11.1	11.3	79.4	95.2	14.3	14.4	1,134.7	1,306.4
NON-EU: DIESEL	1	0	13.8	-	0.1	-	12.4	-	1.4	-
NON-EU: GASOLINE	24	24	14.9	15.2	3.9	4.8	11.5	11.7	54.2	65.2
2000										
EU: DIESEL	75	0	16.2	-	51.0	-	13.0	-	1,404.0	-
EU: GASOLINE	84	84	14.9	15.5	37.3	81.0	14.0	14.1	987.1	1,613.9
NON-EU: DIESEL	20	0	17.2	-	2.7	-	11.1	-	63.1	-
NON-EU: GASOLINE	50	50	13.7	14.2	9.1	19.0	13.4	13.7	191.8	307.8

“Base” refers to benchmark equilibrium in the data while “CF” refers to the equilibrium without diesels cars. “Price” is the average price faced by consumers (in thousands of 1994 Euros), including tariffs. “Share” is the percent of vehicles sold in the category. “Markup” is the price-cost markup defined as $100 \times \left(\frac{p-c}{p} \right)$ where price does not include tariffs, if applicable. “Profits” are measured in millions of 1994 Euros.

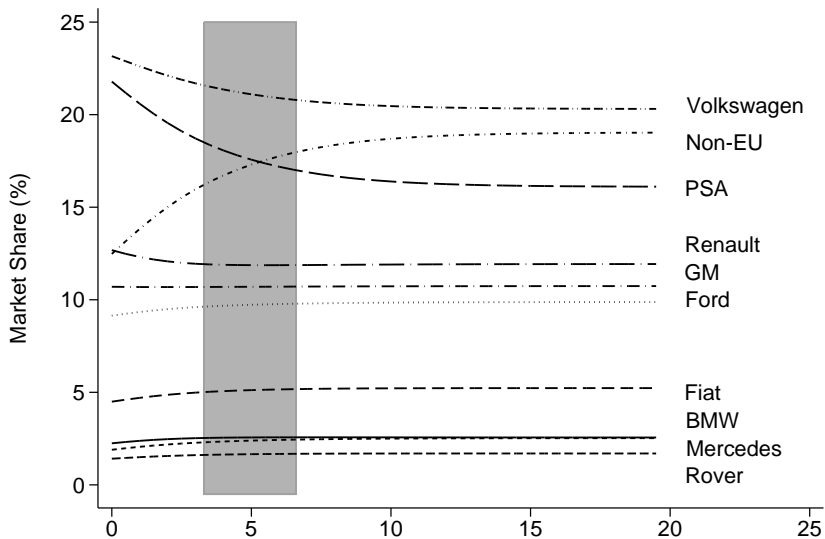
Responses to Stringent Environmental Policies

Table 1: Retrofitting Diesel Engines to meet US Emission Standards

Scenario	Models	CAFE	Price	Quantity	Markup	Share	Profits
Benchmark							
EU: DIESEL	153	51.18	16.04	1,369.82	61.60	49.75	7,842.44
EU: GASOLINE	170	41.57	14.65	1,058.30	67.91	38.43	5,638.64
NON-EU: DIESEL	39	42.85	16.93	68.33	58.84	2.48	313.70
NON-EU: GASOLINE	94	38.87	13.52	257.19	71.58	9.34	1,021.33
Retrofitting expense of 5,000 Euros							
EU: DIESEL	153	50.86	23.07	625.17	45.24	24.04	4,323.81
EU: GASOLINE	170	41.60	14.32	1,573.08	65.12	60.49	8,019.20
NON-EU: DIESEL	39	42.33	24.08	29.05	49.97	1.12	165.43
NON-EU: GASOLINE	94	38.80	13.49	373.05	70.32	14.35	1,457.57
Retrofitting expense of 10,000 Euros							
EU: DIESEL	153	50.67	29.66	300.89	37.73	11.88	2,380.90
EU: GASOLINE	170	41.50	14.52	1,796.85	65.54	70.97	9,303.55
NON-EU: DIESEL	39	42.09	30.86	13.10	44.94	0.52	86.69
NON-EU: GASOLINE	94	38.69	13.75	420.90	71.40	16.63	1,693.02
Retrofitting expense of 20,000 Euros							
EU: DIESEL	153	50.43	42.21	81.75	30.13	3.29	786.27
EU: GASOLINE	170	41.40	14.79	1,947.06	66.22	78.37	10,307.90
NON-EU: DIESEL	39	41.93	43.92	3.16	39.27	0.13	26.06
NON-EU: GASOLINE	94	38.60	14.01	452.42	72.53	18.21	1,875.31

► Current retrofitting costs will limit the viability of diesels.

Effects of Abatement by Firm



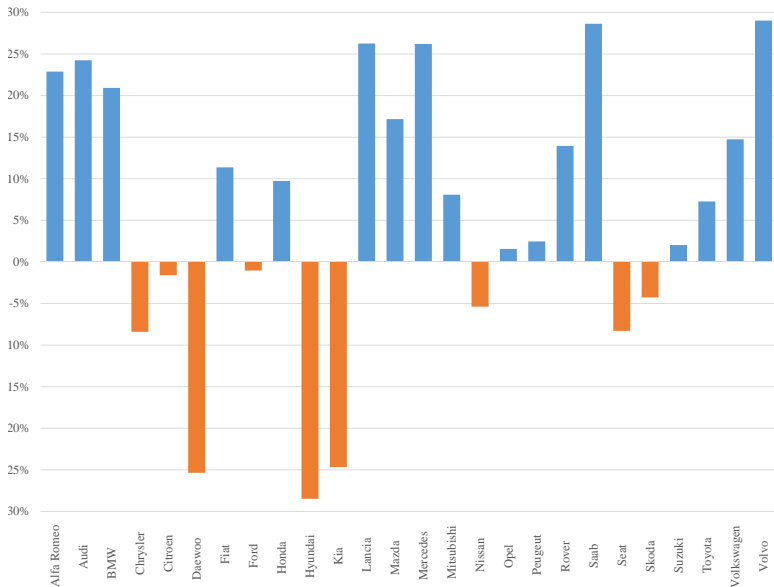
Environmental Policy as a Non-tariff Barrier - Detailed

Table: Value of the Diesel

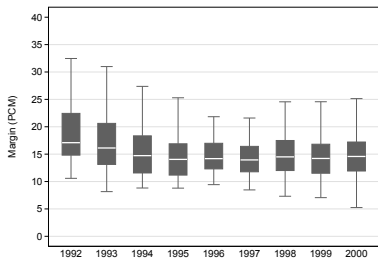
Scenario	Models	Price	Quantity	Margin	Share	Profit
Benchmark						
EU: DIESEL	75	16.19	695.37	18.68	50.95	1,961.00
EU: GASOLINE	84	14.93	508.70	21.09	37.28	1,434.37
NON-EU: DIESEL	20	17.20	36.97	14.84	2.71	83.26
NON-EU: GASOLINE	50	13.66	123.65	21.18	9.06	291.05
No Diesels						
EU: GASOLINE	84	21.11	412.58	16.95	80.40	1,236.29
NON-EU: GASOLINE	50	18.03	100.58	25.83	19.60	394.89

◀ Return

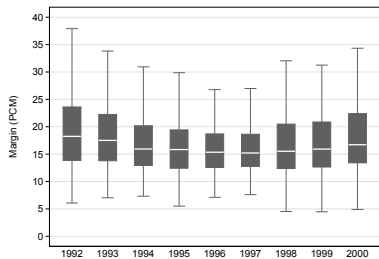
Estimated Brand Cost FEs

[Return](#)


Estimated Price-Cost Margins



(a) Diesel

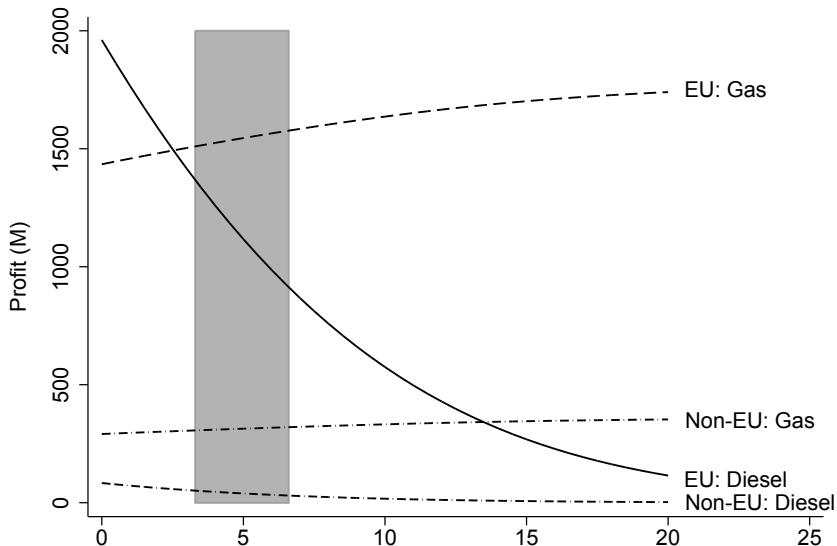


(b) Gas

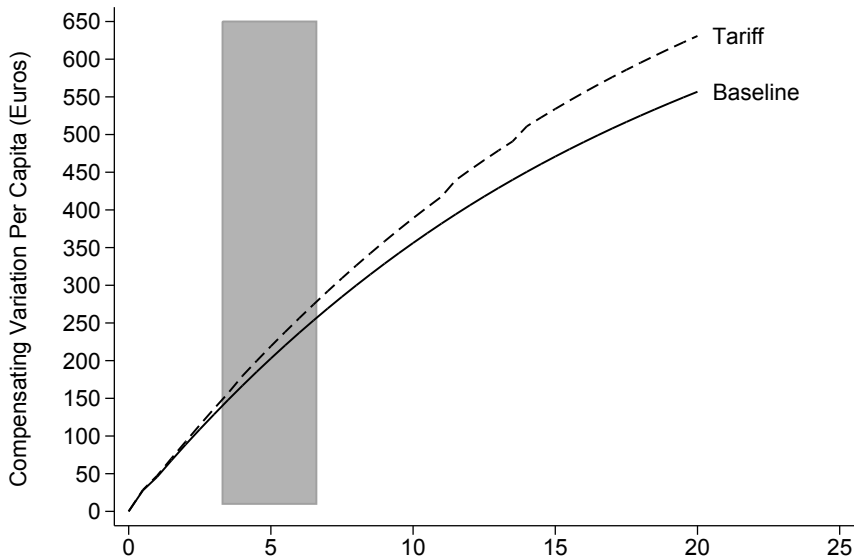
What About the Role of Fuel Taxes?

- ▶ Fuel taxes are much higher in Europe than in the US.
 - 2.6x for gasoline
 - 1.5x for diesel
- ▶ Europeans “subsidize” diesel fuel.
 - European Fuel Taxation Directive of 1973
 - The EU diesel fuel tax is $\approx 2/3$ of the gasoline tax.
- ▶ Since consumers value fuel efficiency ($\sigma_{KPE} > 0$) an increase in fuel tax reduces consumption (and vice-versa):
 - US fuel taxes increase sales of all vehicles, especially gasoline. All automakers benefit.
 - Leveling EU gasoline and diesel taxes shifts consumption to gasoline, but effect is small.

Firm Profits and Retrofitting Costs



Impact of Alternative Emissions Policies on Consumers



Motivation

Figure: Emissions Scandal: VW Market Value Falls 20%

