To Rebate or Not to Rebate: Fuel Economy Standards vs. Feebates

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Environmental regulation

How to go from this

to this...?

Instruments for regulation

- Fuel Economy Standards
  - U.S.: **C**orporate **A**verage **F**uel **E**conomy (CAFE) standards since 1978
  - Minimum level of fuel efficiency that each manufacturer must reach
  - Europe: Mandatory emissions reduction target, fully binding in 2015
- Monetary incentives for consumers: feebates
  - Acquisition or ownership tax related to CO_2 emissions
  - Purchase subsidy for fuel efficient vehicles
  - **Feebate**: combination of purchase tax and subsidy (France)

What we do

- Construct a unifying framework to compare fuel efficiency standards and feebates
- Compare the two instruments when they are equivalent in terms of:
  - Fuel efficiency outcome
  - Tax revenue
- Is one instrument better than the other?
  - Investigate different levels of stringency
  - Two different countries: U.S. and France
- Estimate a structural model of demand and supply for the car industry in the U.S. and France
- Simulate the effects of hypothetical fuel economy standards and feebates

What we find

- Feebate policy is better for both consumer surplus and manufacturers profits
- Robust for different levels of stringency of the policy
- Feebate allows for compensation across manufacturers, conceptually equivalent to imposing a standard allowing manufacturers to trade fuel efficiency levels
- But the two policies have different distributional impacts on manufacturers
- 8 out of 16 manufacturers would prefer the fuel economy standard over the feebate in the U.S. (5 out 18 in France)

- Consumer chooses a car among J different models or not to buy a car (outside option)

- Nested logit model:
  1. Choice of a car segment (compact, SUV, high-end...)
  2. Choice of a car model (Renault Clio, Ford Focus...)

- Consumer obtains utility

$$U_{ij} = \underbrace{\delta_j}_{=X_j\beta+\xi_j} - \alpha p_j + \zeta_{ig} + (1-\sigma)\epsilon_{ij}$$

- Final market share of car model j from segment g is

$$s_j(\delta,\sigma) = s_{j|g}s_g = \frac{\exp((\delta_j - \alpha p_j)/(1-\sigma))}{D_g^{\sigma}\left[\sum_g D_g^{1-\sigma}\right]}$$

- Simple manipulations show that

$$\underbrace{\log s_j}_{\text{mkt share } j} - \underbrace{\log s_0}_{\text{mkt share outside good}} = \delta_j - \alpha p_j + \sigma \times \underbrace{\log s_{j|g}}_{\text{mkt share of } j \text{ given } g}$$

  this is the equation we take to the data

- We use an instrumental variable approach to address the potential endogeneity of price and the intra-segment market share

- Each manufacturer's profits function:

$$\Pi_m = \sum_{j \in \mathcal{M}} N \left(p_j - c_j \right) s_j$$

- N is the number of potential buyers, c_j is the marginal cost
- Actual prices are assumed to satisfy FOCs for the maximization of Π_m

$$\sum_{j \in \mathcal{M}} (p_j - c_j) \frac{\partial s_j}{\partial p_k} + s_k = 0 \; , \quad \forall k \in \mathcal{M}$$

- Matrix of derivatives of market shares w.r.t. prices:

$$\Omega(k, j) = \begin{cases} -\frac{\partial s_j}{\partial p_k} \; , & \text{if } k \text{ and } j \in \mathcal{M} \\ 0 \; , & \text{otherwise} \end{cases}$$

- Optimal vector price (in the absence of policies) satisfies

$$p_j^* = c_j + [\Omega^{-1}S]_j$$

where $\left[\Omega^{-1}S\right]_j$ represents the j^{th} element of the markup vector defined by $\left[\Omega^{-1}S\right]$

Environmental Policies: CAFE

- CAFE standard in the U.S. is defined by the weighted harmonic mean of fuel efficiency (in mpg)
- Equivalently, CAFE standard can be defined by the weighted arithmetic mean of fuel consumption in (gpm)
- Manufacturer's average fuel consumption:

$$e_m(\mathbf{p}) = \frac{\sum_{j \in \mathcal{M}} s_j(\mathbf{p}) e_j}{\sum_{j \in \mathcal{M}} s_j(\mathbf{p})}$$

- Manufacturer sets prices to maximize:

$$\max_{p_{j, j \in \mathcal{M}}} \Pi_m(p_1, \ldots, p_J)$$

$$\text{s.t.} \quad e_m(\mathbf{p}) \leq \bar{e}, \text{ Lagrange multiplier: } \lambda_m$$

Environmental Policies: CAFE

- If $e_m(\mathbf{p}) > \bar{e}$, manufacturer pays fines:

$$F = N \times \sum s_j \times \phi \times (e_m(\mathbf{p}) - \bar{e})$$

where ϕ is penalty per gpm above the standard

Environmental Policies: CAFE

- Three different types of responses:
  - Complier

$$p_j^* = \left(c_j + \lambda_m \frac{(e_j - \bar{e})}{\sum s_j}\right) + \underbrace{\left[\Omega^{-1} S\right]_j}_{\text{markup}}$$

  - Payer

$$p_j^* = (c_j + \phi(e_j - \bar{e})) + \underbrace{\left[\Omega^{-1} S\right]_j}_{\text{markup}}$$

  - Non-affected

$$p_j^* = c_j + \underbrace{\left[\Omega^{-1} S\right]_j}_{\text{markup}}$$

Environmental Policies: Feebate

- We consider linear schemes
- Feebate modifies final prices:

$$p_j^f = p_j + \tau(e_j - \tilde{e})$$

- Manufacturer's optimal price:

$$p_j^f = \left(c_j + \tau(e_j - \tilde{e})\right) + \underbrace{\left[\Omega^{-1} S\right]_j}_{\text{markup}}$$

Making the policies equivalent

- We set the parameters of the CAFE standard: $\bar{e}$ and ϕ

- We solve for the new equilibrium and get: e^{CAFE} and R^{CAFE}

- We solve for the new equilibrium under feebate and the feebate parameters τ and $\tilde{e}$ such that:

    - The same level of fuel efficiency:

$$\frac{\sum_{j=1}^{J} s_j(\mathbf{p}) e_j}{\sum_{j=1}^{J} s_j(\mathbf{p})} = e^{\mathrm{CAFE}}$$

    - The same tax revenue:

$$N\tau \sum_{j=1}^{J} s_j(\mathbf{p}) \times (e_j - \tilde{e}) = R^{\mathrm{CAFE}}$$

Data and estimation results

- U.S.: 3,393 car-models (2000-2007)
- France: 4,142 car-models (2003-2008)

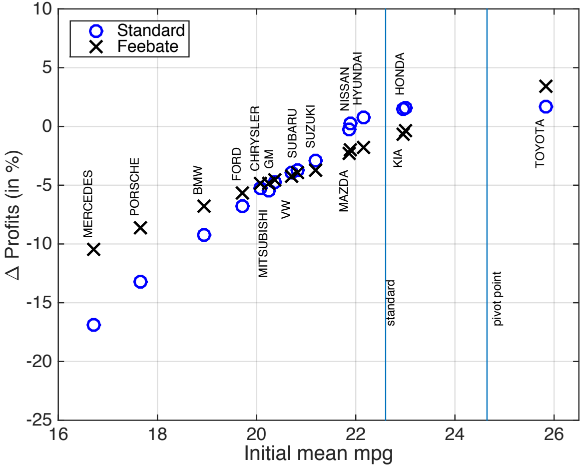
	U.S.		France	
Variable	Parameter	Std err	Parameter	Std err
Price	-0.83^{***}	0.21	-0.76^{***}	0.10
log $s_{j\|g}$	0.13	0.10	0.30^{***}	0.05
Fuel cost	-0.07^{***}	0.03	-0.21^{***}	0.01
Length	0.01^{*}	0.01		
Acceleration	0.02^{***}	0.01		
Weight			0.79^{***}	0.24
Horsepower			0.31^{***}	0.04
Coupe			-0.42^{***}	0.13
Three doors			-0.05	0.10
Wagon			-0.08	0.09
Intercept	-9.29^{***}	1.23	-5.75^{***}	0.37

Simulations: Welfare effects

- Both policies are welfare decreasing
  - Decreases particularly consumer surplus
  - Welfare losses are mitigated by the tax revenues
- Feebate policy is better than standard
  - Because the feebate allows redistribution of fuel efficiency across manufacturers
  - While standard allows redistribution only within manufacturers
  - Fuel efficient manufacturers compensate the least efficient ones (e.g Toyota compensates Porsche)
  - Generates less distortions at the aggregate level

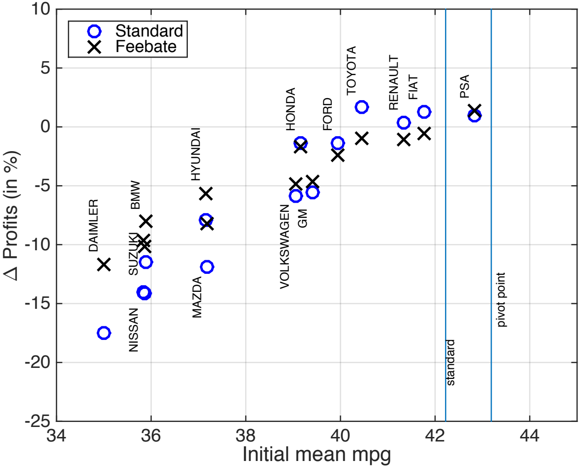
Distributional Effects on Manufacturers

U.S.: 5% increase in standard



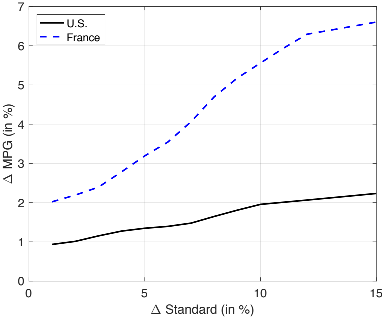
Distributional Effects on Manufacturers

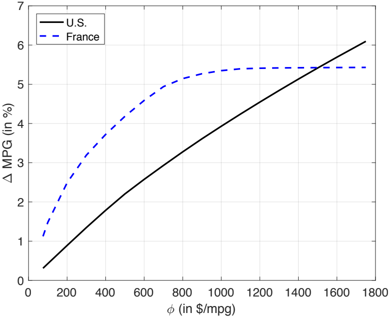
France: 5% increase in standard



Change in the regulation parameters

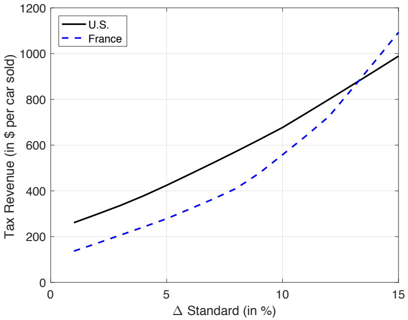
Average mpg

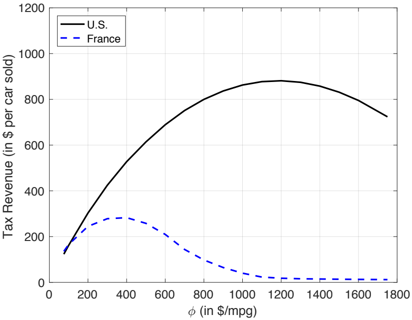




Change in the regulation parameters

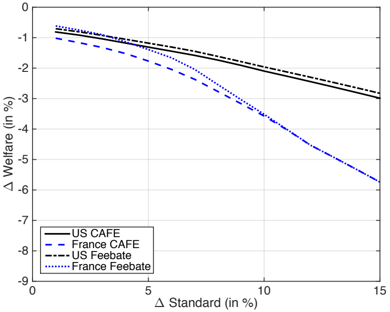
Tax Revenue

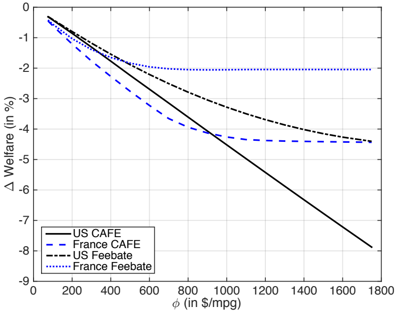




Change in the regulation parameters

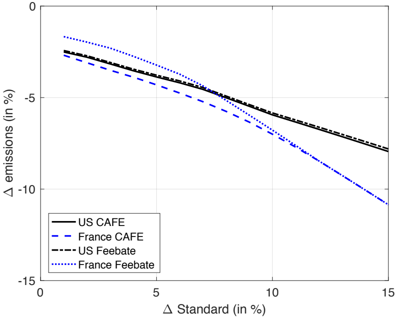
Welfare

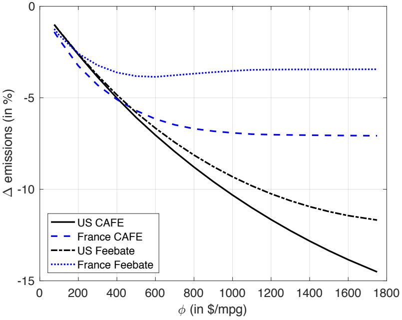




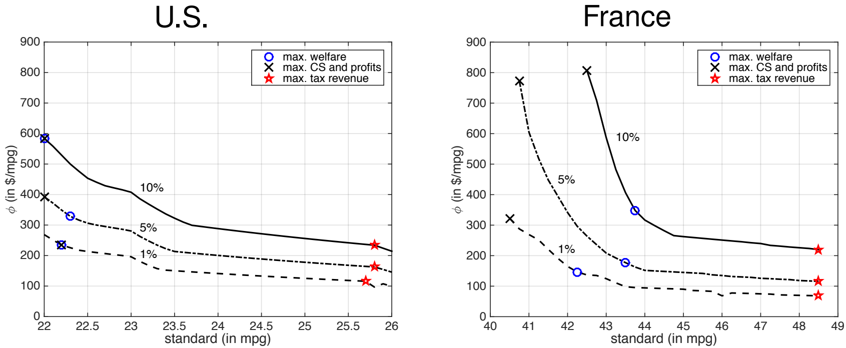
Change in the regulation parameters

CO_2 emissions





Optimal combination of regulation parameters



Benchmark, standard with credits, and attribute-based

	U.S.					France				
				AB					AB	
	S	F	ST	S	F	S	F	ST	S	F
Average mpg	21.82	21.82	21.82	21.75	21.75	41.5	41.5	41.5	42.1	42.1
Tax revenue	3,923	3,923	0	3,617	3,617	315	315	0	31	31
Δ Sales	-2.58	-2.48	-0.17	-2.38	-2.3	-2.8	-2.45	-0.77	-2.1	-2.1
Δ Profits	-2.61	-2.46	-0.07	-2.3	-2.22	-2.56	-2.19	-0.46	-1.67	-1.67
Δ CS	-3.14	-3.03	-0.21	-2.9	-2.81	-3.09	-2.71	-0.85	-2.32	-2.32
Δ CO_2	-3.87	-3.78	-1.5	-3.38	-3.3	-4.3	-3.22	-1.55	-1.13	-1.13
Δ W	-1.31	-1.18	-0.16	-1.17	-1.07	-1.77	-1.39	-0.69	-1.94	-1.94
Δ W (w/CO_2)	-1.29	-1.16	-0.15	-1.15	-1.05	-1.76	-1.38	-0.69	-1.95	-1.95

Notes: All numbers are in percentages except for the first two rows. Tax revenues are in millions of dollars. “W” represents welfare gross of emissions. “W w/CO_2 ” represents welfare net of emissions. We use a value of 36\$/tCO_2 . “AB” stands for attribute-based, “S” for standard, “F” for feebate, and “ST” for standard with trading.

Benchmark, imports, and hybrids: U.S.

	Benchmark		Imports			Hybrids		
	S	F	Initial	S	F	Initial	S	F
Mean mpg	21.82	21.82	21.56	21.86	21.86	21.74	21.98	21.98
Tax revenue	3,923	3,923	38	3,782	3,782	16	3,683	3,683
Δ Sales	-2.58	-2.48	0.27	-2.2	-2.1	0.85	-1.3	-1.19
Δ Profits	-2.61	-2.46	0.29	-2.25	-2.1	0.83	-1.42	-1.27
Δ CS	-3.14	-3.03	0.33	-2.68	-2.56	1.05	-1.59	-1.45
Δ CO_2	-3.87	-3.78	0.09	-3.71	-3.61	-0.14	-3.32	-3.22
Δ W	-1.31	-1.18	0.31	-0.95	-0.82	0.95	-0.01	0.13
Δ W (w/ CO_2)	-1.29	-1.16	0.32	-0.93	-0.8	0.95	0.02	0.16
Imports/Hybrids			0.5	0.65	0.57	4.82	5.15	5.6

Notes: All numbers are in percentages except for the first two rows. Tax revenues are in millions of dollars. “W” represents welfare gross of emissions. “W w/CO_2 ” represents welfare net of emissions. We use a value of 36$/t$CO_2$. “Initial” stands for the initial regulation level, “S” for standard, “F” for feebate. “T1” stands for the gas tax that leads to the same average fuel efficiency (31.6%).

Benchmark and hybrids: France

	Benchmark		Hybrids		
	S	F	Initial	S	F
Mean mpg	41.5	41.5	40.47	41.64	41.64
Tax revenue	315	315	0	272	272
Δ Sales	-2.8	-2.45	1.19	-1.26	-0.87
Δ Profits	-2.56	-2.19	1.06	-1.21	-0.81
Δ CS	-3.09	-2.71	0	-1.4	-0.96
Δ CO_2	-4.3	-3.22	-6.83	-11.35	-11.04
Δ W	-1.77	-1.39	0.43	-0.36	0.06
Δ W (w/ CO_2)	-1.76	-1.38	0.46	-0.32	0.09
Hybrids			2.28	3.02	2.86

Notes: All numbers are in percentages except for the first two rows. Tax revenues are in millions of dollars. "W" represents welfare gross of emissions. "W w/CO_2 " represents welfare net of emissions. We use a value of 36\$/tCO_2 . "Initial" stands for the initial situation without policy, "S" for standard, "F" for feebate.

Conclusion

- We develop a unifying framework to compare the CAFE and feebate policies
- Compare the two policies when they are equivalent in terms of fuel efficiency outcome and tax revenue
- We compare the effects on profits and consumers' surplus
- The feebate is always better if we consider aggregate levels of profits, consumer surplus and welfare
- ...but the two policies imply different distributional effects on manufacturers
- Some manufacturers are better off under the standard regulation