Winners and Losers: Distributional Effects of the French Feebate Policy

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Outline

Presentation of the French feebate

Feebate policy: fee/rebate for new car purchases, introduced in 2008 following “Grenelle Environnement” (10-year anniversary yesterday!)

Tax/subsidy related to the value of CO_2 emissions of the car:

- Cars with CO_2 emissions greater than 160g are taxed: fee between 200 and 2,600 euros
- Cars with CO_2 emissions lower than 130g are subsidized: rebate between 200 and 1,000 euros

By nature, this policy implies winners and losers

Objective of the paper

Quantify the heterogeneous effects of the feebate policy

1. In terms of monetary gains and losses
    - Identify winners and losers among consumers and producers, analyze distributional effects
2. In terms of environmental outcomes
    - CO_2 emissions
    - Air quality: emissions of carbon monoxide (CO), nitrogen oxide (NO_x), hydrocarbons (HC) and particulate matters (PM)

Methodology

1. Estimation of a structural model of demand and supply that describes the automobile market
   - Incorporates a high dimension of individual heterogeneity in preferences
   - Price competition between multi-product firms with differentiated products
   - Structural model of demand and supply à la Berry, Levinsohn & Pakes (1995)

2. Simulation of the market equilibrium without the feebate policy
   - Equilibrium prices and market shares of different car models without the feebate
   - Compute the average emissions of the new car fleet absent the feebate

Methodology

Why do we need a structural model?

Comparison before/after cannot measure the effect of the regulation

- Producers have reacted!
- Policy has distorted consumers choice
- We need to know the underlying preferences of consumers to compute gains and losses due to the choice distortion
- Need a price sensitivity parameter to convert gains and losses from the choice distortion in monetary terms
- Need to estimate car manufacturers margins to measure profits gains/losses

Data

Registrations of new cars:

- Sales of new cars by car model at the municipality level 2003 and 2008
- Prices and car characteristics
- Complemented with data on average demographic characteristics of households at the municipality level (income, household size, professional activity, urban area)

Cars' emissions:

- Average CO_2 emissions observed for each car model
- Data on emissions of CO, NO_x, HC and PM by car model for 2012-2015
- Use this dataset to predict past emissions levels for car models 2008 from observable car characteristics

Related Literature

Large literature on environmental regulation in the automobile market

On hypothetical feebate policies:

- Adamou et al. (EJ, 2013): simulation of an hypothetical feebate scheme in Germany
- Durrmeyer & Samano (EJ, 2017): comparison between standards ($\sim$ U.S. CAFE standards) and feebates

French "Bonus/malus" policy:

- Boutin, D'Haultfœuille et Givord (EJ, 2013): short and long run environmental effects of the policy
- D'Haultfœuille, Durrmeyer, Février (IJIO, 2016): factors explaining the decrease in CO_2 emissions over the period 2003-2008
- D'Haultfœuille, Durrmeyer, Février (Revue Économique, 2011): predictability of the cost of the "bonus/malus"

Outline

The feebate policy

Rebate/fee according to existing classes of CO_2 emissions

Class of emissions	Emissions (in g/km)	Bonus/ penalty
A	(60-100]	+1000€
B	(100-120]	+700€
C+	(120-130]	+200€
C-	(130-140]	0€
D	(140-160]	0€
E+	(160-165]	-200€
E-	(165-200]	-750€
F	(200-250]	-1600€
G	> 250	-2600€

Average CO_2 decreased by 9g between 2007 and 2008 vs. previous trend of 3g/year

Average rebate by municipality

Correlation between average rebate and demographic characteristics across municipalities

	Average rebate
Median Income	2.3
Median Income^2	-0.22**
Household size	
With children	-
Without children	-102.0**
Single	-100.0**
Size of municipality	
Rural (<20,00 inh.)	-
Urban	-10.0
Very urban (>200,000 inh.)	0.24

	Average rebate
Prof. activity	
Retired	-
Farmer	-85.6**
Entrepreneur	-151.6**
Executive	26.0
Intermediate	18.3
Employee	-88.3**
Manual labourer	17.0
Other	4.0
Nb. obs: 30,889	

Outline

Model of demand

Follows the standard BLP model

Model the choice of one car among the models proposed

Consumers have preferences for car characteristics (horsepower, fuel cost, weight...)

Preferences depend on the average demographic characteristics of the municipality and some unobserved terms which distributions are parameterized

Model: equations

Note: t = index for the municipality

Utility is a linear function of products characteristics:

$$U_{ijt} \quad = \quad X_j \beta_{it} - \alpha_{it} p_j + \xi_j + \epsilon_{ijt}$$

Individual parameters as function of town observed demographic characteristics and individual unobserved term:

$$\beta_{it} = \bar{\beta} + \Sigma^{X,o} D_t + \Sigma^{X,u} \zeta_{it}^{u}$$
$$\alpha_{it} = \bar{\alpha} + \Sigma^{p,o} D_t + \Sigma^{p,u} \zeta_{it}^{p}$$

Individual utility decomposed into a mean component (δ), a municipality-specific term (μ_{jt}^{o}) and an individual-specific term (μ_{ijt}^{u}):

$$U_{ijt} \quad = \delta_j + \mu_{jt}^{o} + \mu_{ijt}^{u} + \epsilon_{ijt}$$

Model: equations II

Because of the logistic assumption on the ϵ_{ijt}:

$$s_{ijt} = \frac{\exp\left(\delta_j + \mu^o_{jt} + \mu^u_{ijt}\right)}{\sum_{k=0}^{J} \exp\left(\delta_k + \mu^o_{kt} + \mu^u_{ikt}\right)}$$

Aggregate market shares at the national level:

$$s_j = \sum_t \Phi_t \int_\zeta \frac{\exp\left(\delta_j + \mu^o_{jt} + \mu^u_{ijt}(\zeta_i)\right)}{\sum_{k=0}^{J} \exp\left(\delta_k + \mu^o_{kt} + \mu^u_{ikt}(\zeta_i)\right)} dF(\zeta)$$

Supply model: Nash-Betrand equilibrium

Optimal prices for the set of car $\mathcal{M}$ of a manufacturer satisfy:

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

Estimation methods

Theoretical moments are matched to their empirical counterparts:

- Market shares of car models at the national level ("aggregate moments")
- Covariance between average car characteristics and demographic characteristics at the municipality level ("micro moments")

Why not using market shares at the municipality level directly?

- Sales at the municipality level give imprecise estimators of the true market shares
- Problem of zero market shares, many car models have zero sales

Estimation method

Estimation by generalized method of moments

- ξ are the unobservable characteristics, non-linear function of parameters and the data
- ξ are likely to be correlated to price, price is endogeneous
- Use instruments Z that are correlated to price and uncorrelated to the unobservables
- Moments based on orthogonality conditions $(\xi Z) = 0$
- Complemented with micro moments: $cov(D_t, \bar{X}_t) = \widehat{cov}(D_t, \bar{X}_t)$

Additional details :

- Select a sample of towns (here: 3,000 $\simeq$ 10%)
- Draw individual taste for $ns = 10$ individuals in each municipality
- Dimension of integration to compute market shares = 10 $\times$ 3,000
- Number of products: 4,722 (for 6 years)

Estimation results

	No hetero	Obs. hetero	Obs. & unobs. hetero
Price	-1.07	-1.98	-2.01
Price $\times$ Income		0.525	0.426
Price $\times$ ν_i^P			0.129
Driving cost	-0.319	-0.952	-0.533
Driving cost $\times$ Income		0.087	0.189
Driving cost $\times$ Urban		0.699	
Driving cost $\times$ ν_i^D			0.083
Cylinder Cap.	-0.03	-0.236	-0.06
Cylinder Cap. $\times$ Income			-0.007
Cylinder Cap. $\times$ ν_i^C			0.007
Horsepower	0.175	0.1	0.194
Weight	0.22	0.936	0.315
Urban$\times$weight		-0.479	
Couple w/ children $\times$weight		0.439	
Couple with children $\times$weight		-1.64	
Coupe	-0.263	-0.329	-0.156
Station wagon	-0.758	-0.774	-0.816
Intercept	-8.67	-7.2	-5.6
Intercept $\times$ Income			0.539
Intercept $\times$ ν_i^C			1.12

Outline

Global effects

	Feebate	No Feebate
Share of car purchase	18.51%	18.15%
Total sales	131,470	128,944
French manuf. (in million euros)	551.97	535.22
All manuf. (in million euros)	967.29	949.27
Consumer surplus (in million euros)	1,258	1,236
Δ CS (in million euros, %)	+22.3 (+1.75%)	
$\Delta\Pi_f$ (in million euros, %)	+16.8 (+1.86%)	
State budget (in million euros)	-25.2	
Total welfare (in million euros)	+13.9 (+0.67%)	

Heterogeneity across municipalities

	Average	Min	Max	Nb of town	Nb. households (in thousand)
Without deficit compensation					
Indiv. Surplus	31.4	-135	52	3,000	710.4
Indiv. Surplus >0	31.6	0	52	2,997	709.1
Indiv. Surplus <0	-0.19	-135	0	3	1.3
Total households surplus	+22.3 M€				
With deficit compensation, lump-sum tax					
Indiv. Surplus	-4	-171	17.4	3,000	710.4
Indiv. Surplus >0	2	0	17.4	957	214.9
Indiv. Surplus <0	-6	-171	0	2,043	495.5
Total households surplus	-2.8 M€				
With deficit compensation, proportional income tax					
Indiv. Surplus	-4	-210	12	3,000	710.4
Indiv. Surplus >0	0.4	0	12	859	162.0
Indiv. Surplus <0	-4.4	-210	0	2,141	548.4
Total households surplus	-2.8 M€				

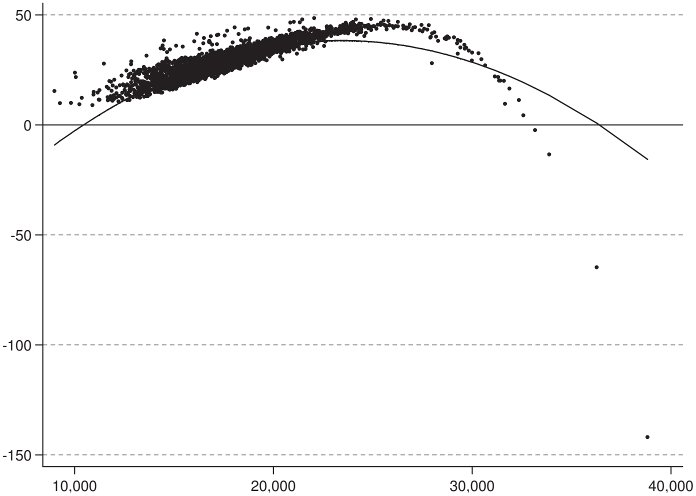
Winners and losers

Correlation between ΔCS_t ($= CS_t^{fee}$ - CS_t^{nofee}) and demographic characteristics, at the municipality level

	ΔCS_t
Income	106.6**
Income^2	-22.8**
Household size	
With children	-
Without children	-0.33
Single	0.21
Size of municipality	
Rural	-
Urban	-0.07
Very urban	-0.77†

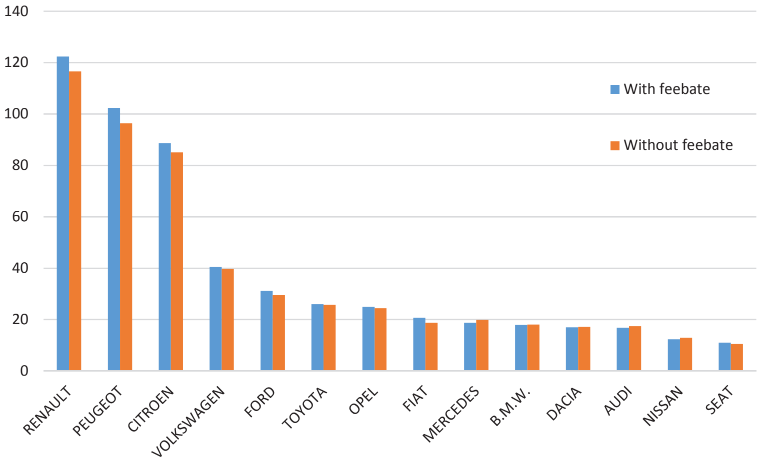
	ΔCS_t
Prof. activity	
Retired	-
Executive	9.94**
Entrepreneur	1.29
Intermediate	2.1
Employee	-3.0
Manual laborer	-6.5**
Farmer	6.9**
Other	1.5

Correlation to income



On the supply side

Annual profits of the major brands with and without the feebate



Environmental effects

Reduced-form equations to predict emission levels of pollutants as function of car characteristics from years 2012-2015

- Main observable characteristics: horsepower, weight, CO_2 emissions (+ powers 2, 3, and 4),
- Dummies for: diesel, automatic transmission, station wagon, convertible, Euro 6 norm
- Trend, trend$\times$ diesel
- Car model and year fixed effects

Prediction of emissions levels for car models 2008

- Use observable characteristics, car model fixed effect
- If car model unobserved, use average fixed effect of the segment
- Extrapolate the trends
- Use difference Euro5/Euro 6 to predict Euro 4

Regressions

Global environmental effects

	With feebate	Without feebate	Variation (%)
CO_2	137.7	140.1	-1.73
CO	38.11	37.85	0.68
NO_X	17.99	17.9	0.5
HC	19.69	19.62	0.32
PM	35.19	35.38	-0.56

Notes: CO_2 are in g/km, NO_x, CO, HC are in mg/km, PM are in mg/10 km.

Environmental effects

Correlation between the variation of pollutant levels and demographic characteristics at the municipality level

	CO_2 (g/km)	CO (mg/km)	NO_x (mg/km)	HC (mg/km)	PM (mg/10km)
Income	0.255*	-0.049*	0.022†	0.068**	-0.072**
Income^2	-0.041	0.012*	-0.003	-0.013*	0.026
Urban	0.01	-0.004	0.002	0.005	-0.001
Very urban	0.088**	-0.022**	0.007*	0.023**	-0.004
Intercept	-2.70**	0.302**	0.064**	-0.015	-0.151**

Reduction in CO_2 comes from low and high income, rural municipalities
CO decrease the most in middle income and very urban municipalities
NO_x increased the richest and very urban municipalities
HC increased the most in middle income, very urban municipalities
PM decrease the most in rich municipalities

Conclusion

First step in quantifying the heterogenous effects of the French bonus/malus for 2008

Overall positive welfare effects and decrease in CO_2 emissions mitigated by an increase of CO, NO_x and HC

Evidence of heterogeneous effects:

- Monetary gains appear to be the highest for middle class households
- Very few rich households experience large losses
- Executive and farmers associated with the highest monetary gains
- Manual labourers associated with the highest monetary loss
- CO_2 emissions reduction is larger in low and high income, rural municipalities
- Increase of CO, NO_x and HC in very large cities

Detail of regression results

	NO_x		PM		CO		HC	
Diesel	18.9**	0.07	9.2*	4.3	3.3**	0.28	-0.43*	0.17
Horsepower	0.28**	0.04	-9.4**	3.2	0.99**	0.15	-0.29**	0.03
Weight	0.57**	0.01	0.73	0.94	1.3**	0.05	0.11**	0.01
CO_2 emissions	-0.47**	0.03	9**	2.6	1.1**	0.12	-0.23**	0.02
Euro 6 norm	-4.5**	0.04	5.8*	2.6	1.7**	0.16	-0.43**	0.02
Trend	2.1**	0.03	1.9	1.5	-1.6**	0.12	0	0.02
Trend×diesel	-2.3**	0.02	-2.9*	1.2	1.6**	0.09	-0.28**	0.08
Automatic	0.23**	0.02	2.8*	1.3	-4.3**	0.1	0.19**	0.02
Station wagon	0.67**	0.04	-0.04	2.6	1.7**	0.19	0.1**	0.03
Convertible	0.63**	0.05	-2.8	3	-1.9**	0.22	0.2**	0.03
2014	-0.1**	0.04	-3.2†	2	0.85**	0.16	-0.02	0.02
2015	-1.7**	0.06	-17.2**	3.5	3.2**	0.27	-0.05	0.05
Intercept	-216**	4.9	-733	432	-476**	20.8	-27.6**	3.3
No obs	75687		35442		75687		17335	
R^2	0.9265		0.1643		0.5162		0.518	

Reading notes: All the regressions include model name fixed effects and the powers 2, 3 and 4 of horsepower, weight and CO_2 emissions.

Table: Regression of pollutants on car characteristics.

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