Winners and Losers: Distributional Effects of the French "Bonus/Malus" Policy on the New Car Market

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Outline

Presentation

Feebate policy: tax/subsidy for new car purchases starting in 2008

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

Feebate scheme designed to be neutral for the state budget

By nature, this policy implies winners and losers

This paper

Evaluation of the policy effect in 2008

1. Measure monetary gains and losses
   - Identify winners and losers among consumers and producers, analyze distributional effects
2. Measure environmental effects
   - On the average CO_2 emissions
   - On average emissions of local pollutants: carbon monoxide, nitrogen oxide, fine particles and hydrocarbons

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. Counter-factual simulation of the market equilibrium without the feebate policy
   - Simulation of prices and market shares of different car models without the feebate

Methodology

Why 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 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 manufacturers margins to measure profits gains/losses

Data

Registrations of new cars:

- Sales of new cars by car model at the municipality level
- Prices and car characteristics
- Between 2003 and 2008
- Complemented with data on average demographic characteristics of households at the municipality level (income, household size, professional activity, votes for the 2007 presidential election)

Pollutants:

- Average CO_2 emissions observed for each car model
- Data on pollutants by car model for 2012-2015
- Use this dataset to predict past pollutant levels for car models 2008 from observable characteristics

Outline

The 2008 Bonus/Malus policy

Feebate scheme: 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€

Main objective: Reduce CO_2 emissions from new cars

Average CO_2 decreased by 9g vs. previous trend of 3g

Additional objective: zero cost, rebates should be subsidized by fees

Annual budget deficit = 244 M€

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 distribution is 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-side: 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 ("macro 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?

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

	Logit	Micro-BLP
Price	-1.07	-2.01
Price × Income	-	0.426
Price × ν_i^P	-	0.129
Driving cost	-0.319	-0.533
Driving cost × Income	-	0.189
Driving cost × ν_i^D	-	0.083
Cylinder Cap.	-0.03	-0.06
Cylinder Cap. × Income	-	-0.007
Cylinder Cap. × ν_i^C	-	0.007
Horsepower	0.175	0.194
Weight	0.220	0.315
Coupe	-0.263	-0.156
Wagon	-0.758	-0.816
Intercept	-8.67	-5.6
Intercept × Income	-	0.539
Intercept × ν_i^C	-	1.12

Outline

Welfare 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%)	

Welfare effects at the municipality level

	Average	Min	Max	Nb of town	Nb. households (in thousand)
Without deficit subvention					
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 subvention by a 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	2043	495.5
Total households surplus	-2.8 M€				
With deficit subvention by a proportional income tax					
Indiv. Surplus	-4	-210	12	3,000	710.4
Indiv. Surplus >0	0.4	0	12	859	162.0
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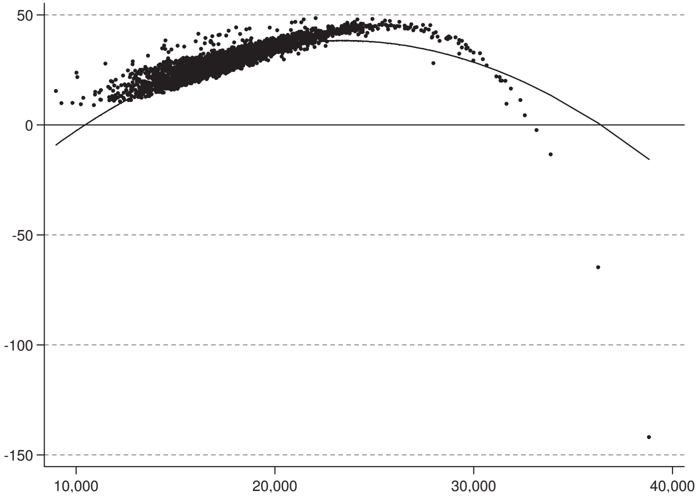
Winners and losers

Correlation between ΔCS 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†

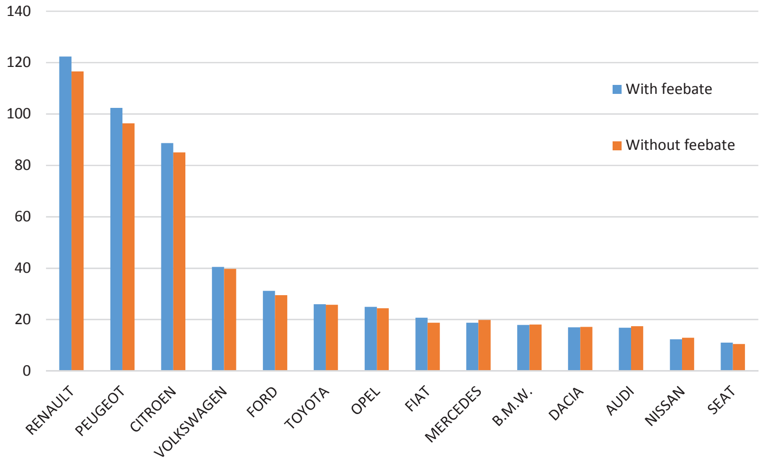
	ΔCS_t
Prof. activity	
Retired	-
Executive	9.94**
Entrepreneur	1.29
Intermediate	2.1
Employee	-3.0
Manual laborer	-6.5**
Farmer	6.9**
Other	1.5
Votes	
Right party	6.2**
Left party	6.0**

Correlation to income



On the supply-side

Annual profits of the major brands with and without the feebate



Environmental effects

Model to predict emission levels of pollutants as function of car characteristics from years 2012-2015

Simultaneous equations for carbon monoxide, and nitrogen oxide estimated on 64,253 car models ($R^2_{CO} = 0.57$, $R^2_{NO_x} = 0.93$)

$$\begin{cases} CO_j = a_0 + a_1 NO_{xj} + a_2 CO_{2j} + a_3 FT_j + a_4 HP_j + a_5 W_j + a_6 t + \epsilon_j^{CO} \\ NO_{xj} = b_0 + b_1 CO_j + b_2 CO_{2j} + b_3 FT_j + b_4 HP_j + b_5 W_j + b_6 t + \epsilon_j^{NO_x} \end{cases}$$

With model fixed effects, body style, squared terms

Model for particles estimated on 30,094 car models ($R^2 = 0.28$):

$$Part_j = c_0 + c_1 CO_j + c_2 NO_{xj} + c_3 CO_{2j} + c_4 FT_j + c_5 HP_j + c_6 W_j + c_7 t + \epsilon_j^{Part}$$

Model for hydrocarbons, estimated on 11,995 car models ($R^2 = 0.61$):

$$HC_j = d_0 + d_1 CO_j + d_2 NO_{xj} + d_3 CO_{2j} + d_4 FT_j + d_5 HP_j + d_6 W_j + d_7 t + \epsilon_j^{HC}$$

Note: diesel positively associated to all pollutants except monoxide

Environmental effects

	Observed	Without feebate	Variation
CO_2 emissions	137.67	140.05	-1.7%
Carbon monoxide	0.356	0.358	-0.43%
Nitrogen oxide	0.09	0.095	-0.71%
Fine particles	5×10^{-3}	4.9×10^{-3}	$+1.3\%$
Hydrocarbons	4.24×10^{-2}	4.20×10^{-2}	$+1.1\%$

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)	Particles (mg/km)	Hydrocarbons (mg/km)
Income	0.256*	0.472**	0.086**	0.0065**	-0.089**
Income^2	-0.04	-0.11*	-0.015*	-0.0015**	0.017*
Size of municipality					
Rural	-	-	-	-	-
Urban	0.010	0.024	0.003	0.0004	-0.0038
+200,000 inhab	0.088**	0.16**	0.024**	0.0019**	-0.025**

Non-linearity for the income: pollutants decrease the most in poor and rich municipalities

Pollutants decrease the most in rural areas and small cities

Conclusion

Evaluation of the French bonus/malus for 2008

Overall positive welfare effects and decrease of the level of all pollutants except particles and hydrocarbons

Evidence of heterogeneous effects:

- Monetary gains appear to be highest for middle class households
- Very few rich households experience larger losses
- Executive and farmers associated with the highest monetary gains
- Manual laborers associated with the highest monetary loss
- Pollutants decrease less in very large cities