

*The Willingness to pay for global warming reduction.
Lessons from the French automobile market.*

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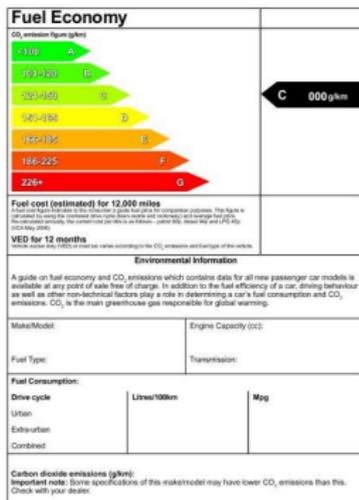
INTRODUCTION : ENVIRONMENTAL REGULATION

Automobile transportation = 20% CO₂ emissions in 2009

Two environmental policies in the 2000's :

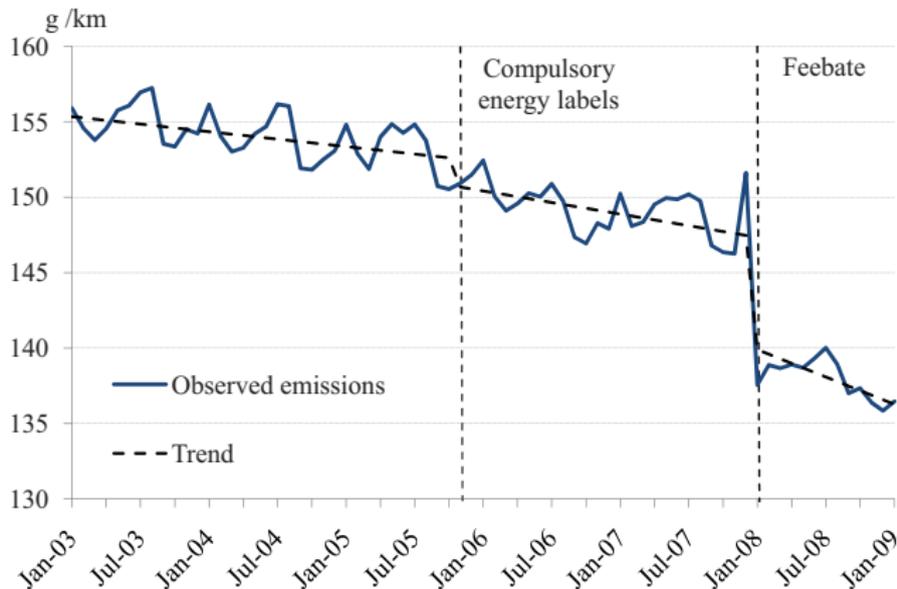
*Compulsory energy label,
November 2005*

*Bonus/penalty policy,
January 2008 :*



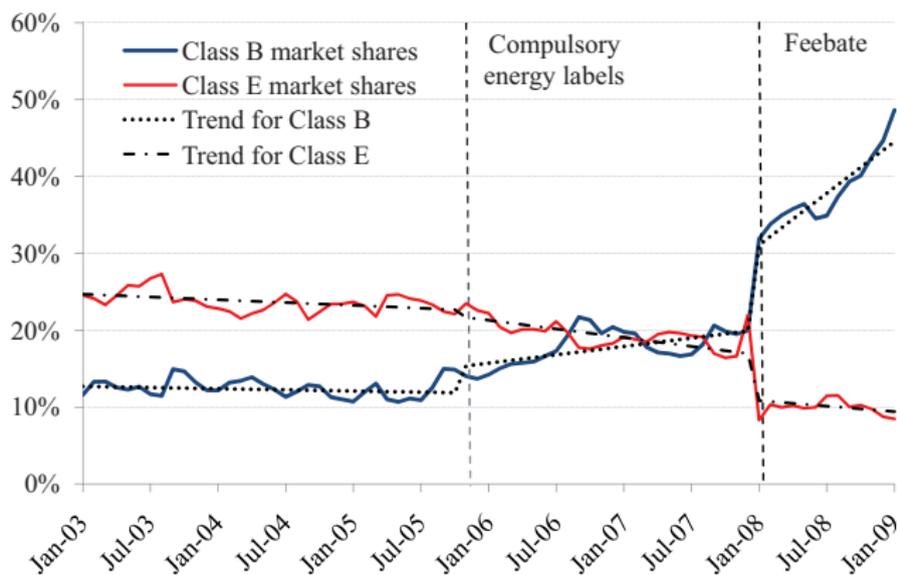
Class of emissions	Emissions (in g/km)	Bonus/penalty
A	(60-100]	+1000€
B	(100-120]	+700€
C+	(120-130]	+200€
C-	(130-140]	0€
D	(140-160]	0€
E+	(160-165]	-200€
E-	(165-200]	-750€
F	(200-250]	-1600€
G	> 250	-2600€

CO₂ EMISSIONS OF NEW VEHICLES PURCHASED



General decreasing trend + shifts after environmental policies

EVOLUTION OF MARKET SHARES



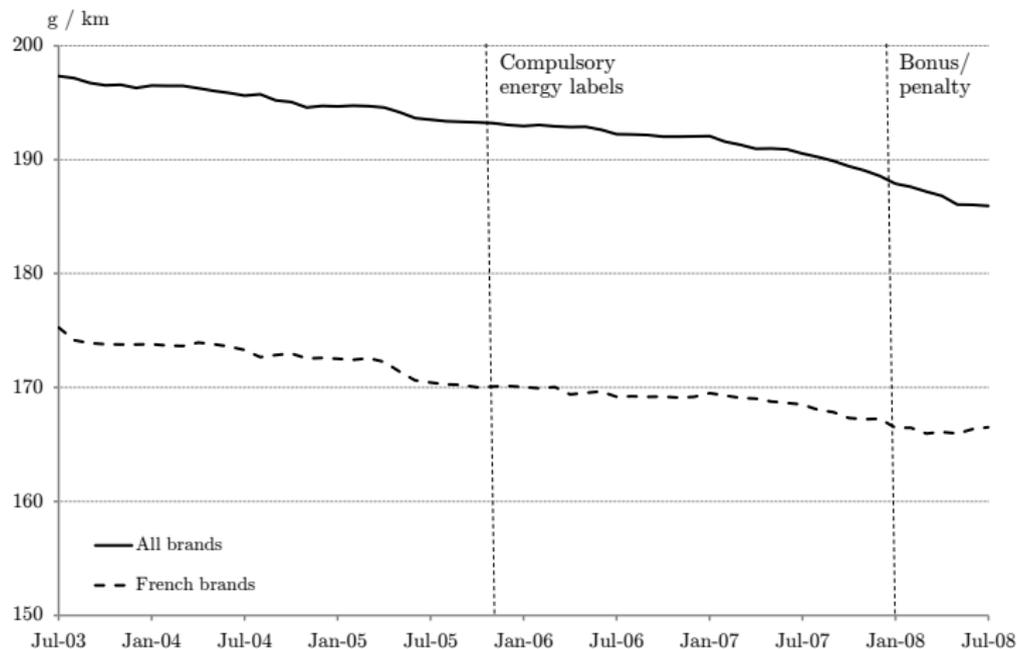
Important shift of market shares...

POTENTIAL EXPLANATIONS ?

...difficult to rationalize with the monetary effect of the feebate only :

Class of emissions	CO ₂ emissions	Malus	Market shares		Mean price	Average ratio malus /price
			2007	2008		
B	[101,120]	-700€	19.9%	38.4%	15,647€	4.7%
E+	[160,165]	+200€	2.9%	2.0%	20,172€	1.2%
E-	[166,200]	+750€	15.1%	7.8%	29,910€	2.8%

CO₂ EMISSIONS OF VEHICLES SUPPLIED



Technical progress but no adjustment after policies

Decrease of CO₂ emissions related to :

① Supply-side effects :

- Technical progress
- No immediate reaction to the feebate policy :
Bonus/penalty announced two months before its application
Certification of new vehicles is a long process
Conducted at French level only

② Demand-side effects :

- Monetary incentive effect of the bonus/penalty policy
- Reaction to evolution of gasoline prices
- **Shift in environmental preference**

⇒ Our approach allows to disentangle these effects

MAIN QUESTION

Does (a growing) environmental concern appear through purchase of new car between 2003 and 2008 ?

*We estimate the preference for environmental quality of vehicles
Effects on the evolution of CO₂ emissions*

Main results :

- Difficult to estimate *per se* preference for environmental attribute...
- ...But possible to estimate **the evolution** of this preference
- Positive and significant evolution of this preference, in line with the timing of the environmental policies
- WTP increased by 536€ between 2003 and 2008 (in average)
- 20% decrease of CO₂ emissions explained by shifts in environmental preferences

ASSESSMENT OF ENVIRONMENTAL PREFERENCE

Estimate a structural model of demand for automobile that incorporates environmental attribute, from market-level data

Utility function is modeled and its parameters are estimated

Traditional approaches in environmental valuation :

- Contingent analysis : Brownstone & al. (2000), Kishi & Satoh (2005)
- Conjoint analysis : Potoglou & Kanaroglou (2007)
Based on stated preferences, problem of hypothetical bias
- Hedonic pricing : difficult to apply to automobile market

Our approach relies on a structural model estimated with market data (revealed preferences)

Source : CCFA (Comité des Constructeurs Français d'Automobile)

Purchases of new cars by French households between Jan. 2003 and Jan. 2009, monthly and by department

Characteristics of the cars :

- Brand, model, CO₂ emissions, horsepower, weight, nb of seats, type of gas, nb of doors
- Prices : retail prices

Some individual characteristics :

- Precise town
- Age
- Income (approximated)

1 MODEL OF DEMAND

2 RESULTS

3 ROBUSTNESS

Berry (1994), Berry & al. (1995) : Nested Logit and Random coefficients models

Our strategy : Nested Logit with observed heterogeneity

- Cars are nested into homogenous groups
- Each consumer purchases one car within the set available or chooses not to buy any (**outside option**)
- Consumers have preferences for vehicles attributes **and** environmental quality : the utility is linearly dependant on attributes
- Consumers with same demographic characteristics have same preferences

Utility of consumer i , with demographic characteristics d purchasing good k

UTILITY FUNCTION :

$$\begin{aligned} U_{ik}^d &= -\beta^d p_k + \gamma^d X_k + \xi_k^d + \zeta_{ig}^d + (1 - \sigma^d) \varepsilon_{ik}^d \\ &= \delta_k^d + \zeta_{ig}^d + (1 - \sigma^d) \varepsilon_{ik}^d \end{aligned}$$

X_k and ξ_k : observable and unobservable characteristics

ζ_{ig} : group-specific error term

ε_{ik} : product-specific error term, iid following an E.V distribution

Property : $\zeta_{ig}^d + (1 - \sigma^d) \varepsilon_{ik}^d \sim E.V. \text{ distribution so that :}$

$$s_k^d = \frac{\exp^{\delta_k^d / (1 - \sigma^d)}}{D_g^{d(\sigma)} \times \sum_{g'=0}^G D_{g'}^{(1 - \sigma^d)}} \quad \text{with : } D_g^d = \sum_{j \in \mathcal{J}_g} \exp^{\delta_j^d / (1 - \sigma^d)}$$

Interpretation of σ^d : intra-group correlation $\in [0, 1]$

β^d represents the price sensitivity, must be positive

Normalisation : $\delta_0^d = 0$

EQUATION TO ESTIMATE

$$\ln s_k^d - \ln s_0^d = -\beta^d p_k + \gamma^d X_k + \sigma^d \ln \bar{s}_{k/g}^d + \xi_k^d$$

Estimation technique : linear model, **IV method**

Endogenous variables : price and intra-group market-share

Identification strategy : existence of instruments

- Correlated with $\bar{s}_{k/g}^d$, p_k but uncorrelated with ξ_k^d
- As usual : functions of other products characteristics

Control variables (X_k) :

- Continuous characteristics : Price (net feebate), horsepower, weight, km/€ (monetary variables in euro 2008)
- Discrete characteristics : Car body style, fuel type, number of doors
- Fixed effects : model, time

Environmental characteristic : CO₂ emissions, CO₂ emissions × years

Definition of 18 demographic groups :

- Age class ([18-29], [30-59], [≥ 60])
- Income class ([0-22 000], [22 000-32 000], [$\geq 32 000$])
- Rural area vs. urban area

Restrictions imposed on parameters :

- Same intra-group variance : $\sigma_d = \sigma \quad \forall d$
- Parameters linear in each demographic component

1 MODEL OF DEMAND

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3 ROBUSTNESS

ESTIMATION OF PREFERENCES PARAMETERS

Estimated parameters of preference for vehicle attributes (bases and deviations) :

	Base	Urban	Age∈[40 ;59]	Age≥ 60	Medium income	High income
Price	0.144**	-0.017**	-0.042**	-0.069**	-0.010*	-0.030**
Weight	0.157**	-0.009	-0.037**	-0.116**	0.002	-0.016
Horsepower	0.154**	-0.024*	-0.130**	-0.239**	-0.018	-0.052**
Km/€	0.047**	-0.007	-0.042**	-0.072**	-0.010	-0.027**
Cylinder capacity	0.045**	-0.003	-0.003	0.016**	-0.003	-0.010**
Station-wagon	-0.404**	-0.060**	-0.004	-0.083**	0.015	0.043*
Convertible	0.081	-0.013	-0.278**	-0.900**	-0.043	-0.066*
3 doors	-0.204**	0.002	-0.132**	-0.465**	-0.056**	-0.083**
Diesel	0.537**	-0.335**	0.142**	-0.171**	0.081*	0.002

Concl. :

Expected signs of parameters and significant heterogeneity

$\hat{\sigma} \simeq 0.3$: nested logit relevant model

Average price-elasticity in the population : $\bar{\eta} = -3.14$

Variable	(1)	(2)	(3)
CO ₂ emissions	-0.931** (0.041)	-0.951** (0.042)	-0.936** (0.042)
CO ₂ emissions×Trend	-0.102** (0.006)	-	-
CO ₂ emissions×2004	-	-0.010 (0.024)	-0.062* (0.025)
CO ₂ emissions×2005	-	-0.163** (0.042)	-
CO ₂ emissions×2006	-	-0.249** (0.036)	-
CO ₂ emissions×2007	-	-0.190** (0.041)	-
CO ₂ emissions×2008	-	-0.410** (0.028)	-0.424** (0.028)
CO ₂ emissions×(2005-2007)	-	-	-0.244** (0.038)

(1) : Trend significant

(2) : Significant evolution of environmental preference from 2005

(3) : Two shifts in environmental preference, 2005-2007 and 2008

CO₂ variable not interpreted, may reflect unobservables...

EVOLUTION OF WILLINGNESS TO PAY

$$WTP^d = -\frac{\gamma_{CO_2}^d}{\beta^d}$$

Income/Age		Rural area			Urban area		
		18-39	40-59	≥ 60	18-39	40-59	≥ 60
0-22,000	2005-07	308 (35)	226 (48)	98 (73)	322 (39)	230 (58)	65 (97)
	2008	382 (54)	301 (65)	265 (92)	426 (57)	350 (78)	327 (125)
22,000-32,000	2005-07	312 (37)	223 (49)	74 (81)	327 (41)	227 (60)	25 (114)
	2008	453 (53)	396 (66)	395 (92)	511 (57)	473 (78)	516 (125)
≥ 32,000	2005-07	389 (46)	321 (65)	162 (115)	422 (53)	357 (85)	134 (186)
	2008	611 (66)	630 (91)	772 (140)	709 (74)	811 (116)	1,225 (220)

Average variations in WTP (for a 10g reduction of CO₂ emissions) :

235€ in 2005-2007

536€ in 2008

WHAT IF PREFERENCES DID NOT CHANGE ?

Year	Observed	No shift
2003	152.6	152.6
2004	151.2	151.2
2005	150.1	152.6
2006	146.5	148.9
2007	146.2	148.3
2008	136.6	139.9

Simulation of average CO₂ emissions : decrease by 12,7g

- Technical progress (4.3g in 4 years) \simeq 1.1g/year
- Monetary incentive of the feebate in 2008 (7.3g)

Concl. : The 16g decrease between 2003 and 2008 can be explained by :

- Technical progress (5.5g, 34%)
- Monetary incentive (7.3g, 46%)
- Shift in environmental preference (3.3g, 20%)

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WHAT ABOUT COMPANY CARS PURCHASES ?

	Passenger cars		Company cars	
Price	-0.117**	(0.015)	-0.064**	(0.016)
Price \times urban	0.029**	(0.003)	-0.015*	(0.007)
$\ln(\bar{s})$ (σ)	0.265**	(0.011)	0.292**	(0.023)
Weight	0.132	(0.018)	0.126**	(0.031)
Horsepower	0.055*	(0.023)	-0.033	(0.024)
Km/€	-0.005	(0.004)	-0.025*	(0.012)
Cylinder capacity	0.048**	(0.003)	0.047**	(0.008)
Station wagon car-body	-0.428**	(0.016)	-0.202**	(0.045)
Coupe/convertible	-0.265**	(0.052)	-0.599**	(0.083)
3 doors	-0.471**	(0.015)	-0.668**	(0.047)
Diesel	0.604**	(0.039)	1.04**	(0.090)
CO ₂ emissions	0.923**	(0.046)	-0.765**	(0.189)
CO ₂ \times (2005-2007)	-0.258**	(0.045)	0.070	(0.065)
CO ₂ \times 2008	-0.407**	(0.018)	0.149	(0.106)
Nb. of observations	100 877		13 869	

Concl. : No significant preference for environmental quality from company

WHAT ABOUT PREFERENCE FOR EMISSION CLASSES ?

Another variable to assess environmental preference

"Positive classes"			"Negative classes"		
A × (2004)	-0.028	(0.22)	E+ × (2004)	0.119**	(0.041)
A × (2005-2007)	0.015	(0.180)	E+ × (2005-2007)	-0.064 [†]	(0.034)
A × (2008)	0.793**	(0.171)	E+ × (2008)	-0.228**	(0.040)
B × (2004)	0.004	(0.052)	E- × (2004)	-0.123**	(0.029)
B × (2005-2007)	0.366**	(0.044)	E- × (2005-2007)	-0.189**	(0.024)
B × (2008)	1.08**	(0.049)	E- × (2008)	-0.234**	(0.029)
C+ × (2004)	0.115*	(0.051)	F × (2004)	0.015	(0.031)
C+ × (2005-2007)	0.480**	(0.044)	F × (2005-2007)	-0.082**	(0.030)
C+ × (2008)	0.614**	(0.048)	F × (2008)	-0.171**	(0.059)
C- × (2004)	0.165**	(0.042)	G × (2004)	0.058	(0.039)
C- × (2005-2007)	0.001	(0.034)	G × (2005-2007)	-0.005	(0.055)
C- × (2008)	0.102**	(0.038)	G × (2008)	0.194**	(0.051)

Concl. : Increase in valuation of "positive classes"

Decrease in valuation of "negative classes"

Robust to the introduction of characteristics × Trend

Correlation of WTP to 2007 election results across towns

	Votes	Δ WTP 2005-07	Δ WTP 2008
Green politics (Voynet)	1.57%	694.3** (44.2)	1820** (100)
Left	34.85%	-202.7** (8.60)	-718.3** (19.5)
Centrism (Bayrou)	18.61%	Ref.	Ref.
Right	44.98 %	-58.79** (8.30)	-318.5** (18.8)
Constant	-	294.1** (6.72)	876.3** (15.3)
Nb. of observations	29,967		

Concl. : Interpretation as environmental preference

Main results :

- Evidence of a growing environmental concern
- Likely related to environmental policies
- Suggests that besides incentive effects, feebate policy shifted environmental preferences

Question about predictability of policy effects ?