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

(Preliminary, please do not cite)*

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Abstract

In this paper, I estimate the distributional effects of an environmental policy across consumers in the French automobile market. In the beginning of 2008, new automobile purchases became subject to a new CO_2 related tax/subsidy (feebate). Exploiting data on aggregate sales at the municipality level complemented by National Survey data on municipality demographic characteristics, I develop and estimate a structural model of demand for new automobile that allows for large heterogeneity in preferences. The use of local data enables me to identify the heterogeneity in preferences by linking average household characteristics in each local town to the attributes of the cars purchased. Using the structural parameters of demand, I compute the welfare gains and losses of consumers and manufacturers and the distribution of consumers' welfare gains and losses across towns. I find that the feebate policy has an overall negative effect : the increase in consumers surplus and French manufacturers profits do not compensate the deficit used to finance the policy. The average individual surplus increases by 49 euros if no tax is introduced to compensate the deficit of the policy, and decreases by 143 euros with a tax. I also find that the welfare gains are positively correlated to the income when the income is lower than 21,000 euros and negatively correlated otherwise so that the policy appears to favor the middle-class income households. I also find evidence that the policy did not favor the government's electors more then its opponent's electors.

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1 Introduction

In 2009, the automobile transportation sector was responsible for 20% of CO_2 emissions worldwide. Several developed countries decided to reduce automobile related emissions through standards that manufacturers must meet (e.g. CAFE standards in the United-States) or taxes (e.g. annual registration CO_2 -based tax in United Kingdom). These instruments have the same objective: increase the value of new fuel efficient environmentally-friendly vehicles and decrease the value of polluting ones. In France, a feebate policy consisting in a nonlinear system of tax/subsidy on the purchase of new cars has been in place since 2008. The purchase of low emissions rate vehicles is encouraged through a bonus and the purchase of high emissions rates vehicles is discouraged through a penalty. Originally designed to be revenue neutral for the State budget, the feebate policy cost 244 million euros in its first year of implementation. Nevertheless, this policy immediately decreased the average emissions of new cars by 16g in the same year.

The objective of the paper is to identify winners and losers of the feebate policy, i.e. evaluate its distributional effects. I focus on the monetary surplus generated by the policy and its distribution across consumers. Such a tax/subsidy scheme always comes with the issue of distributional effects since, by nature, it is designed so that some consumers gain and some lose. I identify here the characteristics of the consumers that are better- or worse-off by the policy. Since the characteristics I use includes income, it also helps to understand to what extent the policy is progressive or regressive. This article focuses on the evaluation of distributional effects across consumers using aggregate-level data on new car purchases.

Using the observations on aggregate-level sales, I recover individual parameters of utility through a structural model of demand for new automobile. The demand model allows for large heterogeneity in preferences for car attributes related to demographic characteristics. The identification of heterogeneity is ensured by using an approach that combines macro and micro moment conditions. The micro moments are constructed by linking the variation in car purchases to the variation in consumers demographic characteristics across municipalities. I simulate the demand for new cars without the feebate policy and evaluate the distribution of gains and losses. I also mitigate the surplus gains and losses with the introduction of a new tax to subsidize the budget deficit. For this adjustment, I consider two tax systems to balance the budget : a lump-sum tax and a proportional income tax.

I find that the policy increases the total consumer surplus only when no tax is introduced to compensate the deficit. The average individual surplus increases by 49 euros without a tax and decreases by 143 euros with a lump-sum tax or a proportional income tax. If majority of consumers are worse-off by the feebate policy, some households experience welfare gains :40 (50) towns are better-off with the feebate and a lump-sum (proportional to income) tax.

The correlation between consumer surplus variation (without tax) and demographic characteristics at the town level shows that the income is positively correlated to welfare gains for an income below 20,000. When the income is greater than 21,000 euros, the income becomes negatively correlated to welfare gains. I also find that voters for both left and right political parties are associated to more gains from the policy.

This paper is related to three papers that focus on the French feebate policy. D'Haultfœuille et al., 2011*b* focus on the bad cost anticipation of the policy. The second companion paper rationalizes the efficiency of the feebate policy with a change of preferences for environmental quality that reinforced the effects of the monetary incentives (see D'Haultfœuille et al., 2011*a*). The paper by d'Haultfoeuille et al., 2013 focuses on the efficiency regarding the environmental outcome.

Also related are papers that evaluate potential or actual environmental policies on the automobile market using a structural approach. For instance, Goldberg, 1998 analyzes the effects of CAFE standards in the United-States. Gramlich, 2010 and Samano, 2011 compare the effects of a potential tax on gasoline with those of an increase in actual CAFE standards regulation. Wakamori, 2011 also evaluates an environmental policy in the Japanese car market: the subsidy for fuel efficient *Kei-Cars*. Huse, 2012 examines the effect of an asymmetric regulation in the Swedish car market: the Green Car Rebate that is awarded under different standards whether the car uses fossil or renewable energy. Finally, Adamou et al., 2013 evaluate the effects of a potential feebate policy in the German automobile market on consumers surplus and manufacturers profits.

This analysis adds to another literature on political economy that models the outcomes of new policies and evaluate the distribution of welfare gains and losses. For instance, Holland et al., 2011 compare actual environmental regulations in the transportation sector (namely ethanol subsidies, renewable fuel standards and low carbon fuel standards) with a more efficient one (cap & trade program) and find that the distribution of welfare gains may explain the persistence of such inefficient regulating policies. A significant number of papers are interested in the distributional effects of gasoline taxes (see Bento et al., 2005, Bento et al., 2009, West, 2004 and West & Williams, 2004). To my knowledge, this is the first paper that analyzes distributional effects across consumers of a feebate policy.

This paper is also related to a large literature in the estimation of demand for automobile using a combination of aggregate and individual data that has followed the seminal article by Berry et al., 1995. Contrary to Berry et al., 2004, Petrin, 2002 and Wakamori, 2011 individual data here do not come from a consumer survey but are the average demographic characteristics of local towns. The data and the approach I use are closer to those used by Nurski & Verboven (2012).

The remainder of the paper is as following. The next section presents the policy. Section 3 is a descriptive analysis of the effects of the feebate policy. In section 4 the demand model is developed. Section 5 focuses on the data and the estimation of structural parameters. Finally, section 6 presents the counterfactual simulation results.

2 Description of the feebate policy

The environmental feebate policy was announced at the end of November 2007 for an application on the 1st of January 2008. It was part of several measures taken by the government following the *Grenelle Environnement* roundtables to deal with environmental issues. The main objective of this policy was to reduce CO_2 emissions related to automobiles. The policy was also supposed to be neutral for the State budget and permanent.

The feebate scheme is defined by values of rebates and taxes associated to classes of CO_2 emissions. The amounts were supposed to remain constant whereas the thresholds were announced to be decreasing by 5g per year from 2010. The rational behind the decrease of thresholds is to take into account technical progress that tends to increase the environmental quality of new cars.

Furthermore, the feebate scheme was designed so the subsidies could be entirely financed by the collected taxes in order to reach the zero cost objective. The cost anticipation turned out to be very bad since the cost reached 244 million euros for the year 2008 and turned out to be even bigger the following years (see Table 1 for the cost of the policy).

Year	Subsidies given	Taxes collected	Balance
2008	469	225	-244
2009	730	200	-530
2010	696	186	-510
2011	423	207	-216

For 2009 and 2010, subsidies include the *Superbonus* of 2000 euros given for the purchase of new liquefied petroleum gas cars. It represents around 100 million euros each year.

Table 1: Expenses and revenues from the environmental bonus/penalty policy (in M€)

Because of the chronical deficit of the policy, the government adjusted the scheme every year since 2010 (see Table 2 for the initial scheme and its evolution). For instance, the bonus for class B decreased from 700€ to 500€, the bonus for the class C+ moved from 200€ to 100€ while the penalty amounts remained unchanged. Despite these changes, the policy remained largely in deficit with a cost of 510M€ for the year 2010. Some more important changes were made in 2011: the rebates for classes A and B were decreased while the bonus for class C- was suppressed. In 2012, the government decided for the first time to increase the penalties to go along with another decrease of the rebates.

	2008-2009		2010		2011		2012	
Class	Emissions	Penalty	Emissions	Penalty	Emissions	Penalty	Emissions	Penalty
A	]60-100]	-1000	]60-95]	-1000	]60-90]	-800	]60-90]	-400
B	]100-120]	-700	]95-115]	-500	]90-110]	-400	]90-110]	-100
C+	]120-130]	-200	]115-125]	-100	]110-120]	0	]110-120]	0
C-	]130-140]	0	]125-135]	0	]120-130]	0	]120-140]	0
D	]140-160]	0	]135-155]	0	]130-150]	0	]140-150]	+200
E+	]160-165]	+200	]155-160]	+200	]150-155]	+200	]150-155]	+500
E-	]165-200]	+750	]160-195]	+750	]155-190]	+750	]155-190]	+750/+1300
F	]200-250]	+1600	]195-245]	+1600	]190-240]	+1600	]190-230]	+2300
G	> 250	+2600	> 245	+2600	>240	+2600	> 240	+3600

Table 2: Feebate schemes between 2008 and 2012 (emissions in g/km, penalties in €)

An unexpected change in the scheme occurred in August 2012 as one of the first reforms of the new socialist government with an increase in rebates and the introduction of new subsidies for electric vehicles. The new rebate scheme was clearly announced as part of a support plan to the French automobile industry in the crisis context and an instrument to subsidize their investment in electric technology. The government announced in October the changes in the penalty scheme for 2013: the future scheme will involve 10 classes of CO_2 emissions related to a tax from 135g/km, with penalties between 100 and 6000 euros. If such feebate schemes are used as instruments to support automobile manufacturers, it is important to measure their impacts on consumers and their distributional effects across consumers.

3 Model

In this section, I present a model to describe the demand and supply for new automobile and the regulator of the industry. The model allows for heterogeneity of preferences related to demographic characteristics. The demand is represented by a random coefficients logit model similar to Berry et al. (1995). The supply-side model describes the competition across price-setting multi-products manufacturers. Finally, we represent the objective of the regulator which depends on consumers surplus, national manufacturers' profits and environmental outcome.

3.1 Demand

The demand is derived from the specification of individual choices. The model allows for a large dimension of unobserved heterogeneity of preferences related to demographic characteristics. The estimation of heterogeneity is possible by taking advantage of micro-level and constructing additional micro moments as Berry et al. (2004) and Petrin (2002) suggest. Instead of using survey data, I use detailed data on sales at the local town level complemented with National Survey data on average demographic characteristics inside towns as Nurski & Verboven (2012).

We consider N potential buyers choose either to purchase one of the J products offered or not to buy any, which is the outside option (denoted by 0). Each product can be seen as a bundle of characteristics: consumers do not have preferences for the products but for the attributes of the products. Each consumer i is utility maximizer, and the utility of choosing the product j is supposed to be a linear function of its characteristics and its price. The index t stands for the town.

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

X_j and ξ_j represent respectively observed and unobserved characteristics and p_j is the price. ϵ_{ijt} is an individual and product specific term which is assumed to be i.i.d with an Extreme Value distribution. Individual parameters of preferences β_{it} and α_{it} are random coefficients as they can be decomposed linearly into a mean, and an individual deviation from the mean. This individual deviation is decomposed into a function of demographic characteristics and an unobserved component which is supposed to follow a Normal distribution.

$$\beta_{it} = \bar{\beta} + \Sigma^{X,o}D_{it} + \Sigma^{X,u}\zeta^{u}_{it}$$
$$\alpha_{it} = \bar{\alpha} + \Sigma^{p,o}D_{it} + \Sigma^{p,u}\zeta^{p}_{it}$$

D_{it} represents the demographic characteristics of consumers. Since we do not observe individual characteristics of consumers inside town, we use the average demographic characteristics of the town : $D_{it} = D_t, \forall i$. ζ^u_{it} and ζ^p_{it} represent unobserved tastes and are supposed to be normally distributed.

The mean utility of the outside option is normalized to 0 so that:

$$U_{i0t} = \epsilon_{i0t}$$

The utility function can be expressed as the sum of the mean utility (δ_j), a deviation from this mean related to demographic characteristics of the town (μ^o_{jt}), a deviation related to unobserved individual heterogeneity (μ^u_{ijt}) and an individual error term.

$$U_{ijt} = \delta_j + \mu^o_{jt} + \mu^u_{ijt} + \epsilon_{ijt}$$

Because of the logistic assumption on the ϵ_{ijt}, the individual probability of choosing the good j in the town t has the following closed-form:

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

Then the market share of product j in the town t is the integral over the distribution of ζ^u_{it}:

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

And the aggregate market share of product j, at the country level is :

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

Where Φ_t is the fraction of consumers in each town: $\Phi_t = \frac{N_t}{N}$.

For the estimation, the aggregate market share is matched to observed market shares of products. The town specific market shares are used to compute the micro moments.

3.2 Supply

I consider an oligopolistic market with a finite number of firms selling differentiated products. These firms are multi-products and set prices taking into account the demand. Profit of firm m producing the set of good $\mathcal{M}$:

$$\pi_m = \sum_{j \in \mathcal{M}} N s_j(p^d) \times (p_j - c_j)$$

N is the number of potential buyers, s_j is the market share of product j that depends, among others, on prices of all other products. c_j is the marginal cost. The optimal price p_j derived from the profit maximization is such that:

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

Each firm is supposed to perfectly anticipate the distribution of price sensitivities in the population and post the optimal prices[1]. The expression using vectors can be written as:

$$S + \Omega(P - C) = 0$$

[1] In this setting firms do not price discriminate and the posted prices are assumed to be equal to transaction prices. See D'Haultfœuille et al., 2012 for more details on introducing unobserved price discrimination in structural models of demand and supply.

And the optimal prices are:

$$P = C - (\Omega)^{-1} S$$

The matrix Ω is the matrix of semi price elasticities and is defined as:

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

3.3 The feebate scheme and the regulator objective

The regulation of the automobile industry is done by choosing a feebate scheme denoted by F. This feebate scheme is composed by a system of fees or rebates associated to any level of CO_2 emissions. Let f_k be the feebate associated to the car model k, it is positive for a fee and negative for a rebate. The final price paid by the consumer is then $\tilde{p}_k = p_k + f_k$.

The annual net benefit of the feebate is equal to the total tax collected minus the rebates given:

$$B(F) = \sum_k s_k f_k M$$

If the benefit is negative, the policy creates a deficit that has to be financed by a new consumer tax. I consider two mechanisms to compensate the deficit : a lump-sum tax and a proportional to the income tax.

With a lump-sum tax, the policy deficit is financed equally by all household. Then the lump-sum tax $T_i^l = T^l = \frac{-B}{M}$.

In the second case, the government introduces a new proportional tax to cover the deficit, $T_i^p = \phi R_i$ where ϕ is such that $\sum_i \phi R_i = -B$.

The regulator's program is to choose the feebate scheme that maximizes the welfare objective under the constraint that the environmental outcome targeted is reached and the budget is balanced. The welfare objective is composed by consumers surplus and national manufacturers profits :

$$W(F) = E\left[\sum_i \lambda_i \Delta CS_i(F) + \sum_{m \in \mathcal{F}} \Delta \pi_m(F)\right]$$

where ΔCS_i is the variation of consumer i surplus that depends of the feebate scheme F through the price variations and the new tax that compensates the deficit.

The variation of consumer surplus is measured by compensated variation:

$$\Delta CS_i = \frac{\ln \sum_{j=0}^{J} \exp\left(V_{ij}^1 - \alpha_i T_i\right) - \ln \sum_{j=0}^{J} \exp\left(V_{ij}^0\right)}{\alpha_i}$$

Where V_{ij}^1 stands for the utility of product j for consumer i with the feebate policy and V_{ij}^0 without it. T_i represents the tax necessary to subsidize the deficit created by the feebate.

$\Delta\pi_m$ represents the profit variation of manufacturer m.

λ_i are the welfare weights the regulator place on consumers' surplus relative to manufacturers' profits.

The regulator has an environmental outcome target that is set in terms of average emissions of the new cars purchased:

$$\sum_k s_k c_k M = c^\star$$

I assume that the regulator is submitted to a financial constraint and cannot have a deficit that is greater than $\bar{B}$:

$$\sum_k s_k f_k M \leq \bar{B}$$

3.4 Uncovering regulator's welfare weights

From the observation of the feebate scheme chosen by the regulator, I am interested in estimating the social welfare weights. I assume the weights λ_i are a direct function of individual characteristics:

$$\lambda_i = f(D_i, \theta)$$

I first start with a simple specification for the regulator's welfare weights :

$$\lambda_i = \theta R_i$$

The objective is to recover θ. This can be done by comparing the outcome of alternative feebate schemes. This approach is in the spirit of the moment inequalities approach suggested by Pakes et al. (2007). Consider a set of other feebates scheme satisfying the two conditions, namely the environmental outcome constraint and the financial constraint : $F_n, \quad n \in \{1, ..., N\}$. We know from the assumption on the regulator's behavior that :

$$W(F, \theta) \geq W(F_n, \theta) \qquad \forall n$$

In a first step, I recover a subset of feebate schemes that achieve the same environmental objective with the same deficit : $F_n = \{f_k^n\}$.

I assume the potential feebates have the following form :

$$f_k = a_r \times (c_k - \tilde{c}_L)\mathbb{1}\{c_k < \tilde{c}\} + a_f \times (c_k - \tilde{c})\mathbb{1}\{c_k > \tilde{c}_U\}$$

The regulator has to set three elements : the slope of the rebates (a_r), the slope of the fees (a_f) and the threshold or range where there is no rebate or fee ($[c_L, c_U]$).

As soon as the threshold range is fixed, there is only one value for the slopes (a_r, a_f) such that the feebate satisfies both the environmental condition and the budget constraint. This is done by solving :

$$\begin{cases} \sum_k s_k(a_r, a_f, \tilde{c}_L, \tilde{c}_U)c_k - s_k(a_r, a_f, \tilde{c}_L, \tilde{c}_U)c^\star = 0 \\ \sum_k s_k(a_r, a_f, \tilde{c}_L, \tilde{c}_U)f_k(a_r, a_f, \tilde{c}_L, \tilde{c}_U)M = \bar{B} \end{cases}$$

Using the subset of feebate schemes that satisfy the constraints, I simulate the distributional effects of these alternatives. I compute the consumer surplus variation $\Delta CS_i(F_n)$ and the profit variation $\Delta\Pi_m(F_n)$. The idea is to simulate more extreme feebate schemes (with a higher slope and with a lower slope) to obtain bounds on parameters of interest θ.

4 Data

To estimate the model, I use a combination of two datasets. The first one contains products characteristics and sales of new cars from 2003 to 2008 at the town level. The database is constructed from the records of all the registrations of new cars by households in France (from the syndicate of French manufacturers, CCFA). The second is composed by average demographic characteristics of households for each of the 36569 towns in France that is a combination of different data published by the National Survey Institute (INSEE).[2] In particular, I observe the number of households and the median income every year.

4.1 Sample construction

I consider a sample of 3000 towns drawn from the set of towns in France for which I observe all the demographic characteristics. I cannot use the entire set of towns for tractability reason, to compute aggregate market shares I have to integrate over the towns (nt) and the simulated individuals (ns).[3] Using the selected towns I compute an approximation of the

[2]For towns of less than 5000 inhabitants, some sensitive information such as median income is not reported and I drop the town from the analysis.

[3]Nurski & Verboven (2012) choose to reduce ns to 1 and consider the exhaustive sample for Belgian towns.

aggregate market shares for each products at the national level. I select the town without using weights so I can get sufficient variation in the characteristics of town. Using the selected towns I compute the covariance between demographics and products characteristics across towns, the empirical counterpart of the micro-moment.

I define a car model is a different brand, model, car-body style (sedan, wagon or coupe-convertible), and class of CO_2 emissions. I consider products characteristics of the most frequently purchased version of the car model. I finally obtain 4722 different car models for the six years of observations. I assume the potential market is composed by one fourth of the French households and compute the share of the outside option by subtracting the total number of sales to one fourth of the sum of households of all the selected towns.

Table 3 contains average demographic characteristics of towns for the exhaustive set of towns and the sample constructed. The sample seems to be representative of the overall set of towns in terms of demographic characteristics and characteristics of purchases. The sample of towns selected still provides enough variation in income and sales which is important to estimate heterogeneity related to demographic characteristics. For instance, the median income is between 7,716€ and 38,820€. Note that the variation of income comes from both variations across towns and across time.

	Mean	Std. Dev.	Min	Max
Exhaustive				
Nb. Households	850	7,367	15	1,061,697
Nb. Purchases	361	1038	0	14,011
Median Income	16,226	3,146	5,601	50,696
Price	20,354	8,388	5,995	99,880
CO_2 emissions	149.1	29.6	88	361
Sample				
Nb. Households	907	4,115	22	108,561
Nb. Purchases	326	575	1	3,781
Median Income	16,242	3,145	7,716	38,820
Price	20,252	8,251	5,995	99,880
CO_2 emissions	148.8	29.1	88	361

Table 3: Descriptive statistics for the exhaustive dataset and the sample

4.2 Descriptive analysis

I investigate here the correlation between average new cars characteristics and average demographic characteristics using the sales of new cars at the town level. I regress the average price of cars purchased by town, the frequency of *green* cars (under 130 g/km of

CO_2 emissions) and the frequency of *brown* cars (over 160 g/km of CO_2 emissions) on the average demographic characteristics of the towns. The idea is to analyze how the heterogeneity of car purchases across town is related to the heterogeneity of consumers across towns.

The average demographic characteristics are the median income, the frequency of households according to the household size (family with children, couple without children and single). I also consider the frequency of households according to the professional activity of the head of family (it can be divided in 8 categories: farmer, retired, entrepreneur, executive, intermediate profession, employee, manual labourer and other category). Another characteristic is the type of town : towns of less than 20,000 inhabitants (rural), between 20,000 and 200,000 inhabitants (urban) or up to 200,000 inhabitants and Paris area (very urban). Finally, I use the share of votes in the 2007 presidential election in France. Precisely, I consider the votes during the first round[4] for the two main candidates: the right political party[5] candidate Nicolas Sarkozy, who was actually elected as president and the candidate of the principal left political party SÃ©golÃ¨ne Royal[6] who was defeated in 2007. The feebate policy was initiated by Sarkozy's government, it is thus interesting to see whether the policy favored the actual voters or the voters of the main opponent, the left political party.

Table 4 shows that these demographic characteristics are significantly correlated with the average price of vehicles purchased and the shares of *green* and *brown* cars. More specifically, a high income is associated with more expensive cars and weakly correlated with a lower proportion of *brown* cars. On the other hand, the income is negatively correlated to the proportion of *green* cars. Couples without children are associated with more expensive cars, a higher proportion of *brown* cars and a lower proportion of *green* cars than couples with children. Singles are also related to a higher proportion of *brown* cars and a lower proportion of *green* cars than couples with children. Furthermore, singles are associated with cheaper cars than couples with and without children. Regarding the the professional activity, it can be observed that high education level (entrepreneur, executive and intermediate profession) are associated with more expensive cars, a lower share of *green* cars and a higher share of *brown* cars. The farmer category is also related to more expensive cars and a higher proportion of *brown* cars. Finally, employees are associated with a lower share of *green* cars while manual laborers are associated with a lower share of *brown* cars. Urban and very urban towns are related to lower vehicle prices and a higher share of *green* cars than in rural towns. The share of brown cars is not significantly different whether the town is rural, urban or very urban. It can be observed that votes for the right political

[4] I use the votes for the first round because it provides more variation than in the second round due to the number of other minor parties -10 others-.

[5] The party name is *Union for a Popular Movement*.

[6] The name of the party is *Socialist Party*.

party is associated to more expensive cars than towns in favor of the left political party. Right-oriented towns are more likely to buy brown cars and less likely to buy green cars than the left-oriented ones.

From this correlation analysis, it seems that richer couples without children in rural areas are the ones that buy more expensive cars. Rich households without children living in rural area buy less frequently *green* cars and are thus likely to be worse-off with the feebate policy. It is also the case for entrepreneurs and employees. Regarding the political opinions, voters for the right political party are less likely to buy *green* cars than those that are traditionally left-oriented.

	Price	Green Cars	Brown Cars	Rebate (2008)
Median Income	0.142**	-0.007**	-0.001	2.288
Median Income^2	-0.001**	$0.39\times10^{-4\dagger}$	$1.4\times10^{-4**}$	-0.218**
Household size				
With children	REF	REF	REF	REF
Without children	1.687**	-0.055**	0.059**	-101.969**
Single	-1.693**	-0.103**	0.154**	-100.042**
Prof. Activity				
Retired	REF	REF	REF	REF
Farmer	2.387**	-0.01	0.035**	-85.569**
Entrepreneur	2.49**	-0.07**	0.189**	-151.589**
Executive	0.259	0.012	0.055**	26.021
Intermediate	-0.31†	-0.015†	0.04**	18.289
Employee	-0.343†	-0.032**	0.043**	-88.325**
Manual labourer	0.546**	0.006	-0.012†	16.992
Other	0.129	0.077**	0.001	3.954
Type of town				
Rural	REF	REF	REF	REF
Town urban	-0.104*	-0.02**	0.002	-10.00
Town very urban	-0.286**	-0.011**	-0.001	0.242
Votes				
Right party	4.068**	-0.077**	0.114**	-209.56**
Left party	0.611**	0.02*	-0.052**	12.222
Nb of obs.	180,890			30,889

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

Year fixed-effects included.

Table 4: Regression of average characteristics of cars purchased on average demographics of the town

5 Estimation

The methodology applied here requires first to estimate parameters of utility and costs. I use the GMM based on aggregate moments complemented by micro moments. I follow the standard Berry et al. (1995) approach to construct aggregate demand and supply moments. I use micro moments to ensure the identification of heterogeneity of preferences with respect to demographic characteristics.

5.1 Aggregate moments

The aggregate moment condition is based on the interaction of demand shocks (ξ) with the instruments Z. The demand shocks are such that theoretical market shares are equal to the observed ones:

$$\begin{aligned}&s_j^{obs} = s_j(\delta_j, \theta)\\ &\text{with } \delta_j = X_j\beta + \alpha p_j + \xi_j\end{aligned}$$

θ represents the heterogeneity parameters $(\sigma^{X,o}, \sigma^{X,u}, \sigma^{p,o}, \sigma^{p,u})$. To invert market share equation and recover the vector of mean utilities δ, I use the contraction mapping suggested by Berry et al. (1995).

The price p_j is endogenous that is likely to be correlated with the demand shock ξ_j. Firms have market power and their pricing decision depends on the demand, including the unobserved (to the econometrician) demand shocks. The instruments used are functions of other products characteristics, as in Berry et al. (1995). Under the assumption that products characteristics other than price are exogenous, functions of other products characteristics are exogenous instruments. These instruments are correlated to the price through the competition : firms that has more closer substitutes has less market power and sets a lower price.

More precisely I use three sets of instruments : sum of characteristics of all the other firms products, the sum of characteristics of other products of the same firm and the sum of characteristics of other firms products in the same segment.

$$\sum_{k\in\mathcal{F}',\mathcal{F}'\neq\mathcal{F}} x_k, \sum_{k\in\mathcal{F},k\neq j} x_k, \sum_{k\in\mathcal{F},\mathcal{F}'\neq\mathcal{F},k\in g} x_k$$

Where the index g stands for the segment.[7]

The moment condition is $\mathbb{E}(\xi_j z_j) = 0$ and the sample analogue is given by :

$$G^1(\theta, \alpha, \beta) = \frac{1}{YJ}\sum_y \sum_j \xi_{jy}(\theta, \alpha, \beta) z_{jy}$$

[7] I consider 8 segments : mini, small family, large family, executive, minivans, luxury and sports cars.

Where the index y stands for the year.

In addition to the demand side moment condition, I construct a moment condition from the supply side, starting from the specification of the marginal cost equation :

$$\begin{aligned} mc_j &= X_j\gamma + \omega_j \\ p_j - m_j(\theta, \alpha, \beta) &= X_j\gamma + \omega_j \end{aligned}$$

The moment condition is that the cost shocks are uncorrelated with instruments, $\mathbb{E}(\omega_j z_j) = 0$. I use the sample analogue :

$$G^2(\theta, \alpha, \beta) = \frac{1}{YJ} \sum_y \sum_j \omega_{jy}(\theta, \alpha, \beta) z_{jy}$$

5.2 Micro moments

The micro-moments use the information I have on demographic characteristics and market shares of products at the municipality level. More specifically, I match the empirical covariance between demographic characteristics and products characteristics across products and town to the predicted covariance. The sets of micro-moments are crucial to identify heterogeneity that comes from observable demographic characteristics as suggested by Berry et al. (2004) and Petrin (2002). The third set of micro-moments are :

$$\begin{aligned} G^3(\theta, \alpha, \beta) &= \frac{1}{YJ} \sum_y \sum_j \sum_t s_{jt}^{obs}(x_{jy} - \bar{x})(D_{jt} - \bar{D}) - s_{jt}^{pred}(\theta, \alpha, \beta)(x_{jy} - \bar{x})(D_{jt} - \bar{D}) \\ &= \frac{1}{YJ} \sum_y \sum_j \sum_t s_{jt}^{obs} x_{jy} D_{jt} - s_{jt}^{pred}(\theta, \alpha, \beta) x_{jy} D_{jt} \end{aligned}$$

6 Estimation results

The observed product characteristics introduced in the utility function are the price including the feebate for the year 2008, the cost of driving (represented by the cost -in constant 2008 euros- of driving 100 kilometers), the horsepower, the cylinder capacity, the weight, the type of car-body style (coupe or station-wagon, sedan is the reference) and a dummy if the car has three doors. I also include time and brand fixed effects.

Table 5 represents estimated mean parameters of the utility function. Price has a significant negative coefficient and the price sensitivity decreases with the income. Horsepower, fuel efficiency, cylinder capacity and weight are positively valuated attributes while the utility decreases with the cost of driving. Consumers prefer standard car-body style over coupe and station-wagon.

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

Price and Income are both divided by 10,000 euros and deflated.

Table 5: Estimated parameters

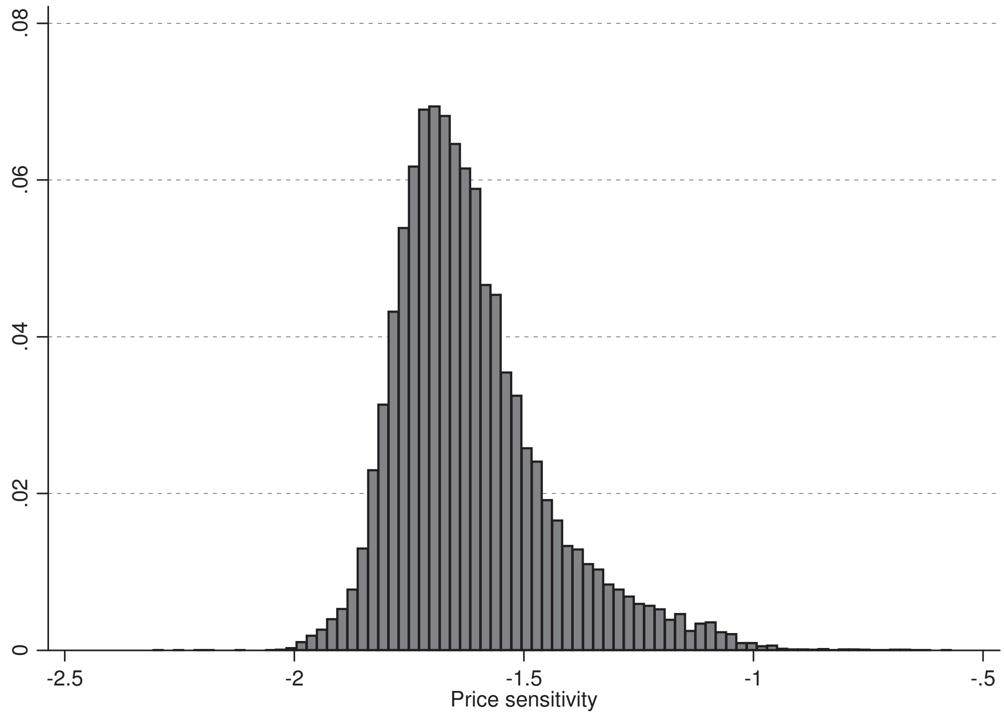

Figure 1: Distribution of price sensitivities

Figure 1 represents the distribution of price sensitivities across individuals. The distribution presents heterogeneity in price sensitivity but it is concentrated between -2 and -1.5.

7 Counterfactual analysis

In this section, I present the results on distributional effects from counterfactual simulations. I first estimate the surplus variation related to the feebate policy by comparing the equilibrium in 2008 with the feebate policy (observed) and the equilibrium without the feebate (simulated). Then I analyze the distributional effects of the feebate policy by correlating welfare gains or losses of a town to the demographic characteristics of its inhabitants. Finally, I investigate alternative feebate schemes and relate their effects to the regulator preferences in terms of redistribution. Note that the welfare analysis is conducted only on the sample of selected towns.

7.1 Welfare analysis

Table 6 presents the global welfare effect of the feebate policy by comparing the market equilibrium with and without the feebate policy. It can be observed that average CO_2

emissions would be significantly higher without the policy (139.3 compared to the actual level of 137.7). Sales would be slightly lower (around 2500 less than with the feebate). Regarding the welfare effects, the feebate has a positive effect on both consumer surplus (+22.3 million euros) and French manufacturers profits (+16.8 million euros) and the gains are sufficient to compensate the deficit created by the policy. Indeed, the total welfare effect is positive (+13.9 million euros)[8].

	Feebate	No Feebate
CO_2 emissions	137.67	139.32
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	
$\Delta\Pi_f$ (in million euros)	+16.8	
Benefit (in million euros)	-25.2	
Total welfare (in million euros)	+13.9	

Table 6: Total welfare effect of the feebate policy

Gains for consumers from the feebate policy are evaluated through their variation of surplus which is measured by compensated variation:

$$\Delta CS_i = \frac{\ln \sum_{j=0}^{J} \exp\left(V_{ij}^1 - \alpha_i T_i\right) - \ln \sum_{j=0}^{J} \exp(V_{ij}^0)}{\alpha_i}$$

Where V_{ij}^1 stands for the utility of product j for consumer i with the feebate policy and V_{ij}^0 without it. T_i represents the tax necessary to subsidize the deficit created by the feebate. I consider three assumptions for the deficit compensation mechanism. In the first one, the deficit is not subsidized by a tax on consumers: $T_i = 0$. I consider a lump-sum tax as a second mechanism to subsidize the deficit: $T_i = \bar{T} = 35.4$ euros. In the third setting, a flat proportional income tax is introduced: $T_t = \phi \frac{R_i}{10{,}000} = 19.4 \times \frac{R_i}{10{,}000}$ euros.

I compute average consumer surplus for each town of the sample and analyze the variation across towns:

$$\Delta CS_t = \int_{i \in t} \frac{\left(\ln \sum_{j=0}^{J} \exp\left(V_{ij}^1 - \alpha_i T_i\right)\right) - \ln \sum_{j=0}^{J} \exp\left(V_{ij}^0\right)}{\alpha_i} dF(\nu_i)$$

[8]This is the total welfare gains and losses for the selected sample of town only (around 10%).

Table 7 represents the variation in the average consumer surplus related to the feebate policy for the different tax mechanisms. Without tax, the policy has a positive effect on consumers surplus with an average increase of 31.4 euros. However the policy has heterogenous effects since average variation of consumer surplus in between -135 euros and +52 euros. However, it can be observed that the policy has positive effect on consumers for the major part of the towns (consumer surplus decreases in only 3 of the 3,000 towns).

With the two tax mechanisms, the average individual welfare effect appears to be modestly negative (-4 euros). Globally the policy appears to be negative for consumer welfare, the increase in consumer surplus is insufficient to balance the deficit, as suggested by Table 6. However there are some winners and losers : in 957 municipalities (859 with a proportional tax) consumers are, in average better-off with the feebate policy. In the next section I investigate the demographics characteristics of the winners and losers.

The two tax mechanisms considered are globally equivalent. A lump-sum tax decreases uniformly all consumers surplus variation by 35.4 euros while a proportional income tax implies negative transfer between 17.4 and 75.4 euros (see the distribution of taxes across towns in Appendix A). Using a proportional tax modifies the range of the distribution of welfare gains and losses which is now between -210 and 12. It is possible to note that the number of households that are worse-off is more important when using the proportional income tax : 548 thousands versus 496 thousands with the lump-sum tax.

	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	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
Indiv. Surplus <0	-4.4	-210	0	2141	548.4
Total households surplus	-2.8 M€				

Table 7: Average consumer surplus variation by town

7.2 Identifying winners and losers

I finally correlate the variation of consumer surplus with demographic characteristics of towns in order to identify winners and losers. I regress the average consumer surplus variation of the town on the average demographic characteristics of the town's households. The correlations are presented in Table 8 and it can be observed that income is positively correlated to welfare gains while the squared income is negatively correlated. The correlation between welfare gain and income is non-linear : while the income is lower than 25,000 euros, the income is positively correlated to gains but when the income is greater than 25,000, a higher income is associated to less welfare gains (see Figure 2 for the illustration of the income effect). While the household size and the type of town appear to be not significantly correlated to the consumer surplus variation, the votes for both the right and the left political parties are positively correlated with increase in consumer surplus.

	ΔCS_t
Income	106.6^{**}
Income^2	-22.8^{**}
Household size	
With children	REF
Without children	-0.33
Single	0.21
Prof. activity	
Retired	REF
Executive	9.94^{**}
Entrepreneur	1.29
Intermediate	2.1
Employee	-3.0
Manual labourer	-6.5^{**}
Farmer	6.9^{**}
Other	1.5
Type of town	
Rural	REF
Urban	-0.07
Very urban	$-0.77^{\dagger}$
Votes	
Right party	6.2^{**}
Left party	6.0^{**}

Note: Income is divided by 10,000 euros.

Number of observations : 3000.

Table 8: Correlation between variation of consumer surplus and demographic characteristics across towns

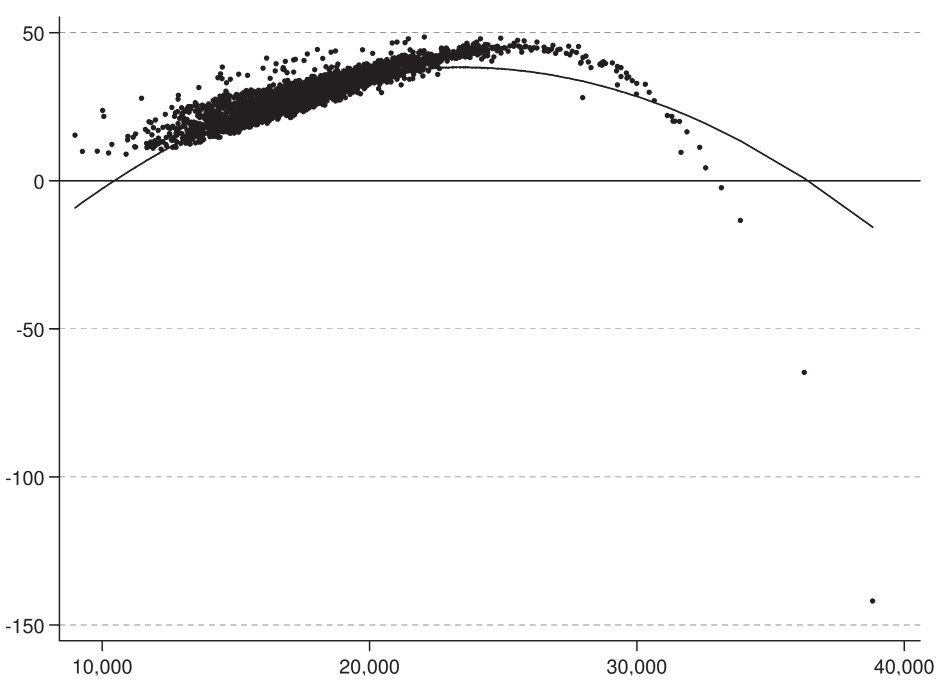

Figure 2: Consumer surplus gains or losses with respect to income (no tax scenario)

8 Conclusion

In this paper, I measure distributional effects of the feebate policy using aggregate data on sales at the town level together with a structural model of demand. I find that the feebate policy increased the global welfare, even with a tax increase to subsidize the deficit created by the policy. Consumers are globally worse-off when a tax is introduced to compensate the deficit but the individual welfare loss is in average modest. Furthermore, I find that the policy has asymmetric effects, some consumers are better-off with the policy.Analyzing the distributional effects, I find that the policy favors the middle class income. and both voters of the government's political party and voters of its main opponent. This analysis will be complemented with the identification of winners and losers on the manufacturers side to have a global analysis of the distributional effects the feebate policy.

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A Additional Figures

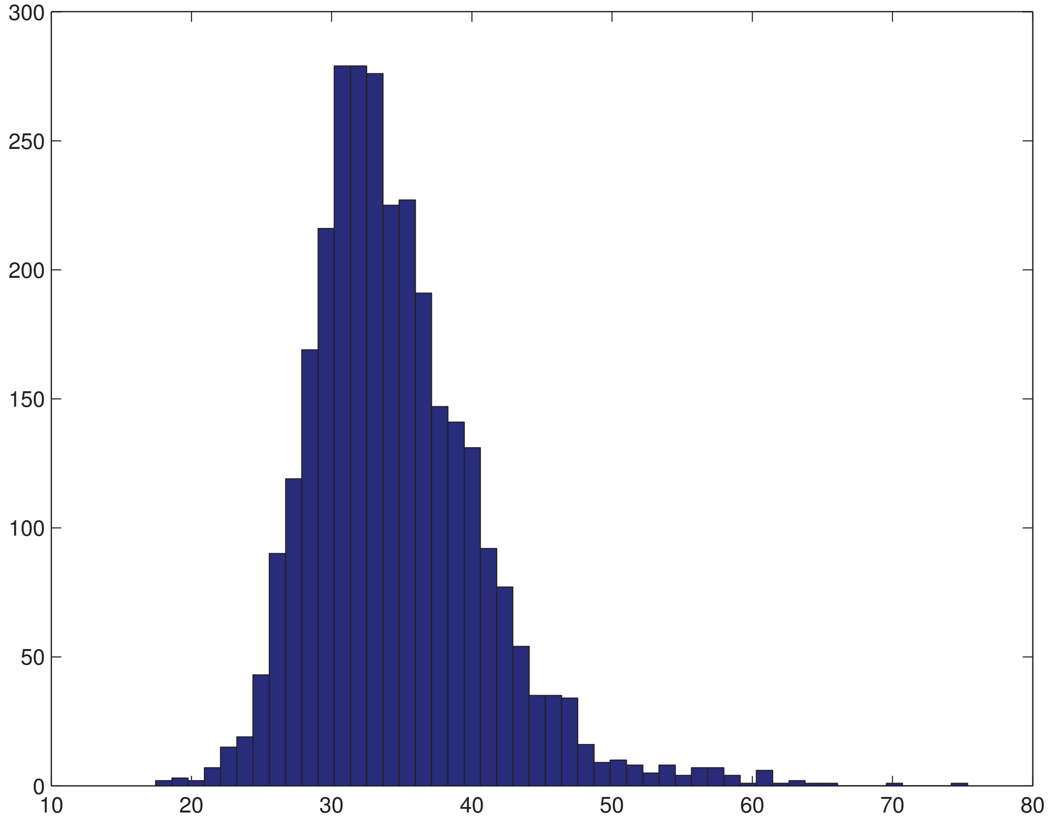

Figure 3: Distribution of proportional income taxes across towns