Market integration and environmental taxation

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Preliminary and incomplete, please do not circulate

Abstract

We quantitatively investigate the importance of parallel imports of new automobiles in Europe and its impact on the effectiveness of environmental regulation. To identify parallel imports, we rely on a structural model of demand that incorporates the choice of importing as opposed to buying from domestic sellers. The identification of the structural model depends on three elements: (i) the observation of the difference between foreign and domestic prices to identify which car models are potentially imported, (ii) the observation of market shares of car models in regions that are located at various distances from the borders, and (iii) the assumption that the probability of importing decreases with the distance. We use the model to study potential leakage effects when countries unilaterally impose regulatory regimes aimed at reducing CO2 emissions from new car sales. Preliminary findings suggest that partially integrated markets can amplify or nullify emissions reductions of taxation schemes, depending on whether tax schemes lead to strong price differences of low-emissions or high-emissions cars, respectively.

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1 Introduction

Private road transport accounts for 12% of global greenhouse gas emissions and policy-makers around the world have implemented policies to curb the emissions of this sector. In the European Union, environmental regulation is imposed both at the EU- and the member state level. Many policies co-exist and overlap. While common in their goal to reduce CO2 emissions from new car sales, these policies often differ in their design, begging the question whether they create unintended consequences by undermining each other or whether they reinforce each other. These questions are especially salient given that it is possible to import cars from other EU countries, creating arbitrage opportunities caused by environmental regulation that could lead to leakage effects.

In this paper, we examine the impact of parallel imports in the automobile market on the effectiveness of environmental regulation. First, we measure the prevalence of parallel imports. Second, we evaluate different environmental policies and study how their effectiveness changes with the level of parallel imports and he design of other co-existing policies. Pricing reactions to policies imposed in different countries can alter relative prices and create arbitrage opportunities. These opportunities can spur parallel imports and ultimately undermine or reinforce the goal of environmental policies. Similarly, different overlapping or co-existing environmental policies across countries can nullify or reinforce each other by generating distortions in relative prices.

We rely on a structural model of demand and supply that incorporates parallel importers. Consumers choose between buying in their home market or importing from abroad. We assume that there are informational frictions or costs that discourage consumers from importing a car. Specifically, we expect consumers to weigh these costs against the potential benefits from importing, which accrue exclusively through lower prices for some cars. On the supply side, we model pricing decisions of car manufacturers at the supernational level. When setting prices in one country, manufacturers take into account the effect of these pricing decisions on sales in the neighboring country via the parallel import channel.

The challenge is that we do not observe sales at the dealer level and do not observe the fraction of cars that are imported. Instead, we rely on the assumption that consumers import to take advantage of lower foreign prices, which actually are observed. Implicitly, we assume that consumers bear a cost of importing, or have a preference for buying directly from a local dealer, and that the choice of importing is the result of an arbitrage between this cost and the benefit of importing, through lower prices. We rely on variation in market shares across different regions within a given country to identify the cost of importing.

We estimate the model using a detailed dataset containing car purchases at the county level in France and Germany. The data is complemented with prices of car models in different European countries. We take advantage of the local variation in the data and assume that the cost of importing depends on the distance between the consumer and the foreign country. Furthermore, we are able to introduce a large set of demographic characteristics to parameterize the cost of importing. On the supply side, manufacturers compete maximize EU-level profits. Firs set prices for each individual country, taking into account the competitive pressure imposed by the parallel importer.

Using the results from the structural model of demand and supply, we first simulate the effect of different environmental taxation regimes. This counterfactual allows us to measure the environmental and welfare effects of the different taxation regimes. In particular, we consider three scenarios: (i) one where all taxes except value added taxes are removed, (ii) one where the French tax regime applies in both countries and (iii) one where the German tax regime applies to both countries. We evaluate all three scenarios at different level of market integration and hence different prevalence of parallel imports. In particular, we evaluate the scenarios at (i) the current level of integration, (ii) completely separated markets, and (iii) fully integrated markets in which the law of one price holds.

Preliminary findings suggest that partially integrated markets can amplify or nullify emissions reductions of taxation schemes, depending on whether tax schemes lead to strong price differences of low-emissions or high-emissions cars, respectively. In particular, we find that the environmental taxes imposed in France and Germany reduce fleet emissions by around 3.7 g/100km. If both countries used the French scheme, fleet emissions would be minimally lower whereas they would be larger if the German scheme was imposed everywhere. Different taxation schemes lead to different import patterns that change the CO2 emissions of cars sold in the two countries. Fleet emissions of cars sold in Germany would be almost 3g/100km lower if German taxes were imposed everywhere. This is because under this scheme, many more French consumers buy cars in Germany. These cars tend to be more less polluting. On the other hand, fleet emissions of cars sold in France would go up.

2 Data and institutional background

2.1 Environmental taxation in France and Germany

Many different taxes must be paid when purchasing a new car. First, the buyer must pay the value added tax (VAT) of his own country as well as registration tax and potential environmental tax (e.g. feebate in France). The VAT rates are 20% for France and 19% for Germany. Second, there are specific car taxes, usually for environmental reasons. The French specific car taxes include: (i) a registration tax which is function of the fiscal horsepower and the rate varies across regions (form €27 to €51.2 in 2017 - source ACEA tax guide), (ii) feebate scheme, cars imported are subject to the tax (malus) which has the following formula in 2017 $2.5 \times (X - 127)^2 + 50$, for X between 127 and 191 g/km, and (iii) tax on ownership only for cars registered for the first time in 2009 and and after, subject to CO2 emissions greater than a threshold that depends on the year.

The German car specific tax system includes: (i) registration fees of €26.3, and (ii) an annual circulation tax that depends on cylinder capacity and emission group (euro norm + fuel type) (before July 2009) and Co2 emissions and cylinder capacity after July 2009.

Transport Transportation of the car from abroad can be done in three different manners: (i) transported by a company or another car or (ii) drive it back to the domestic country with a temporary plate and temporary insurance.

2.2 Data

We use a detailed dataset that contains all the purchases of new cars in France and Germany over the period 2005-2014. We observe the main car characteristics: brand, model, horsepower, fuel consumption, type of fuel, and the body style. We also observe domestic prices. These are list prices, as opposed to transaction prices.[1] For the question of interest here, what is crucial is the difference between domestic and foreign prices and we only observe list prices of the imported cars. The assumption we implicitly make is that the discounts that consumers may obtain over the posted prices are identical irrespective of the car being domestic or imported.

Table 1 shows summary statistics for the sample. Firm prices are the prices that firms set and receive, i.e. net of all taxes and/or subsidies. Consumer prices are the final prices faced and paid by consumers. These prices include all taxes (value added, registration, and 10 times the annual tax). We see that in both countries, firm prices have increased slightly between 2005 and 2014. Increases in taxes mean that consumer prices increased relatively more. Throughout the sample period, average consumer prices were lower in France. Overall, some 60% of products were cheaper in France than in Germany, even though this number fluctuated substantially from year to year, mainly due to changes in relative tax levels. We also see that the average (unweighted) tailpipe CO2 emissions decreased by around 46 grams per 100km .

Figure 1 plots the distribution of price differences. We can see that most products exhibit firm price differences of less than €5,000. Taxes exacerbate these differences. The distribution is widened and pushed to the left, meaning more products become cheaper in France and the price differences increase. The reason is that the French feebate scheme makes many cars with low CO2 emissions cheaper in France than in Germany.

3 Model

We develop a model of demand and supply in which consumers have to search to have access to the imported cars.

[1]See D'Haultfœuille et al. (2014) for a full analysis of this issue.

Table 1: Results

Variable	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Firm price FR	28,237	29,781	30,109	29,208	28,927	30,113	30,221	29,840	30,108	30,296
Final price FR	34,144	36,081	36,437	36,070	35,669	37,045	37,195	36,712	36,735	37,735
Firm price DE	27,849	29,295	29,354	28,356	28,057	28,958	29,052	28,709	28,881	28,800
Final price DE	34,849	36,539	37,431	36,094	35,718	39,219	38,864	38,006	37,821	37,375
Pct cheaper in DE	0.35	0.34	0.29	0.39	0.38	0.21	0.26	0.27	0.32	0.41
Fuel cost FR (€/100km)	10.28	10.60	10.44	10.86	8.67	9.27	9.92	9.82	9.17	8.51
Fuel cost DE (€/100km)	10.24	10.53	10.49	10.68	8.80	9.31	9.87	9.72	8.93	8.22
Fuel economy (L/100km)	7.62	7.62	7.46	7.23	6.88	6.60	6.38	6.12	5.90	5.72
CO2 (g per 100km)	189.13	189.78	186.21	180.78	172.70	165.20	159.52	153.05	147.57	143.20
Weight (kg)	1,932	1,975	1,990	1,998	1,974	1,980	2,000	2,006	2,010	2,014
Horse Power	99.75	106.34	109.24	108.81	107.52	112.09	116.13	115.78	116.47	116.98
Engine size (cm2)	2,046	2,085	2,082	2,043	1,987	1,984	2,007	1,978	1,947	1,912
Diesel share	0.43	0.47	0.49	0.50	0.52	0.51	0.50	0.51	0.51	0.51
Footprint (m2)	7.67	7.75	7.81	7.86	7.80	7.85	7.92	7.99	8.00	8.01
Sales FR	455,083	445,317	464,796	462,255	530,383	484,636	485,515	399,570	379,592	380,478
Sales DE	778,095	794,737	753,359	761,028	928,455	713,209	769,053	741,118	720,856	733,802

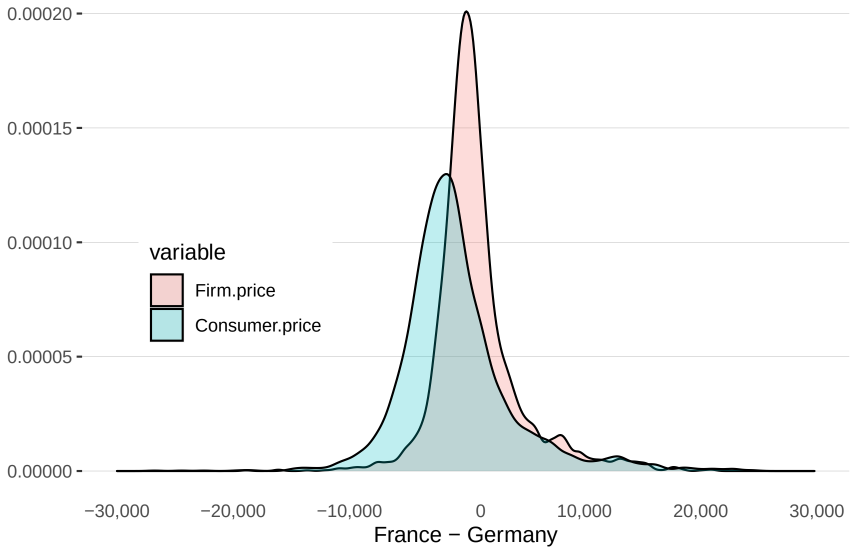

Figure 1: Distribution of price differences

3.1 Demand

We assume that the utility is a linear function of car characteristics and price. We index consumer by i, products by j and country by c. We leave out the time index for simplicity.

$$U_{ij}^c = X_j \beta_i^c + \alpha_i^c p_{ij} + \xi_j^c + \epsilon_{ij}$$

X_j and ξ_j^c are the car characteristics that are respectively observed and unobserved by the econometrician. We allow unobserved characteristics to be valued differently across countries. p_{ij} is the price of the car and it is individual specific as it depends on whether the consumer imports or not and of the distance if he is an importer. α_i represents the price sensitivity. Specifically, the price p_{ij} is equal to $\min_{c'} \left\{ p_j^{c'} + f(d_{i,c'}) \right\}$, where $p_j^{c'}$ stands for the price in country c'. We assume that, except for price, the characteristics of imported vehicles are strictly identical to domestic ones.

As usually, we assume that the idiosyncratic terms ϵ_{ij} are distributed according to a Type 1 extreme value. The probability that consumer i chooses car model j depends on its price and thus on whether the consumer is an importer or not. The probability of buying car model j is:

$$\begin{cases} s^c_{ij/I} = \frac{\exp(X_j\beta^c_i+\alpha^c_i \min_{c'}(p^{c'}_j)+\xi^c_j)}{1+\sum_{j'}\exp(X_{j'}\beta^c_i+\alpha^c_i \min_{c'}(p^{c'}_{j'})+\xi^c_{j'})} & \text{if importer} \\ s^c_{ij/NI} = \frac{\exp(X_j\beta^c_i+\alpha^c_i p^c_j+\xi^c_j)}{1+\sum_{j'}\exp(X_{j'}\beta^c_i+\alpha^c_i p^c_{j'}+\xi^c_{j'})} & \text{if not importer} \end{cases}$$

The status of the buyer (importer or not importer) is the result of the choice of searching or not searching for an imported car. We assume the choice of searching is made before the consumers receive their private product preference shocks. This assumption is also made by Moraga Gonzalez et al. (2015). Let γ_i be the search cost of consumer i. We assume that $\gamma_i = \exp(D_i\theta + \eta_i)$ with η_i following a logistic distribution across consumers, $F(\eta) = \frac{1}{1+\exp(-\eta)}$. Then consumer i decides to search if the expected value of searching is higher than the cost:

$$\gamma_i \le \underbrace{\log\left(1+\sum_j \exp(X_j\beta_i + \alpha_i \min_{c'}(p^{c'}_j + f(d_{i,c'})) + \xi^c_j)\right)}_{IV_I} - \underbrace{\log\left(1+\sum_j \exp(X_j\beta_i + \alpha_i p^c_j + \xi^c_j)\right)}_{IV_{NI}}$$

$$\exp(D_i\theta + \eta_i) \le IV_I - IV_{NI}$$

$$\eta_i \le -D_i\theta + \log(IV_I - IV_{NI})$$

We denote by IV_I the expected value of importing and IV_{NI} the expected value of not importing (i.e. before the individual-product specific shock is realized). Because of the logistic distribution assumption, the probability of searching has a closed form solution:

$$\phi_i = \frac{IV_I - IV_{NI}}{IV_I - IV_{NI} + \exp(\theta D_i)}$$

The importers are consumers with low search costs and those who gain the most from importing. The gains from importing depend on several elements: demographic characteristics, the price difference, the price sensitivity and the preference for car characteristics. If a consumer has a strong taste for a car for which the price differential is high, he is likely to import, even with a high search cost. When there is not gain of arbitrage, i.e. $IV_I = IV_{NI}$ then the probability of importing is 0. The probability of importing is increasing in the gain from import $(IV_I - IV_{NI})$. Thus the probability that consumer i chooses the car model j is:

$$s^c_{ij} = \phi^c_i s^c_{ij/I} + (1-\phi^c_i) s^c_{ij/NI}$$

Thus, the market share of car model j in country c is:

$$s_j^c = \int s_{ij}^c dF(\alpha_i, \beta_i, \gamma_i, d_{i,.})$$

Let $\phi_{i,I}^c$ the probability of importing and $\phi_{i,NI}^c$ the probability of not importing. The quantities purchased and imported in country c are:

$$\begin{aligned} q_j^{c,I} &= \int_i \phi_{i,I}^c s_{ij/I}^c dF(\alpha_i, \beta_i, d_i) M^c \\ q_j^{c,NI} &= \int_i \phi_{i,NI}^c s_{ij/NI}^c dF(\alpha_i, \beta_i, d_i) M^c \end{aligned}$$

where M^c is the size of the country, the number of potential consumers in country c. The derivatives of these quantities appear in the first order conditions of price optimality:

$$\frac{\partial q_j^{c,NI}}{\partial p_j^c} = \int_i \frac{\partial \phi_{i,NI}^c}{\partial p_j^c} s_{ij/NI}^c + \phi_{i,NI}^c \frac{\partial s_{ij/NI}^c}{\partial p_j^c} dF(\alpha_i, \beta_i, d_i) M^c$$

$$\partial \phi_{i,NI}^c / \partial p_j^c = \phi_{i,NI}^c . \frac{\alpha_i (s_{ij/NI}^c - s_{ij/I}^c \mathbb{1}\{p_j^c = \min_{\tilde{c}} p_j^{\tilde{c}}\})}{IV_{i,I}^c - IV_{i,NI}^c + \exp \theta D_i}$$

It is always negative, the probability of not importing decreases with the domestic price. Note that we always have $s_{ij/NI}^c - s_{ij/I}^c \mathbb{1}\{p_j^c = \min_{\tilde{c}} p_j^{\tilde{c}}\} >= 0$ because if the prices of other products are lower, we should expect the market share of product j to be lower.

$$\partial s_{ij/NI}^c / \partial p_j^c = \alpha_i s_{ij/NI}^c (1 - s_{ij/NI}^c)$$

So in the end:

$$\frac{\partial q_j^{c,NI}}{\partial p_j^c} = \int_i \alpha_i \phi_{i,NI}^c s_{ij/NI}^c M^c \left[1 - s_{ij/NI}^c + \frac{s_{ij/NI}^c - s_{ij/I}^c \mathbb{1}\{p_j^c = \min_{\tilde{c}} p_j^{\tilde{c}}\}}{IV_{i,I}^c - IV_{i,NI}^c + \exp \theta D_i} \right]$$

It is negative, as we should expect and if $p_j = \min_{\tilde{c}} p_j^{\tilde{c}}$, then the price p_j^c does not affect the probability of being an importer or a non-importer and we find an expression that is essentially the standard formula:

$$\frac{\partial q_j^{c,NI}}{\partial p_j^c} = \int_i \alpha_i \phi_{i,NI}^c s_{ij/NI}^c M^c \left[1 - s_{ij/NI}^c \right]$$

The cross price derivative is:

$$\frac{\partial q_j^{c,NI}}{\partial p_k^c} = \int_i \alpha_i \phi_{i,NI}^c s_{ij/NI}^c M^c \left[-s_{ik/NI}^c + \frac{s_{ik/NI}^c - s_{ik/I}^c \mathbb{1}\{p_k^c = \min_{\tilde{c}} p_k^{\tilde{c}}\}}{IV_{i,I}^c - IV_{i,NI}^c + \exp \theta D_i} \right]$$

The foreign prices affect demand for product j only through the probability of importing:

$$\frac{\partial q_j^{c,NI}}{\partial p_k^F} = -\phi_{i,NI}^c \alpha_i \frac{s_{ik/I}^c \mathbb{1}\{p_k^F = \min_{\tilde{c}} p_k^{\tilde{c}}\}}{IV_{i,I} - IV_{i,NI} + \exp(\theta D_i)}$$

3.2 Supply

We consider a variant of the standard oligopolistic price competition with differentiated products setting. The novelty is that when setting a price, a seller not only takes into account the demand in a country but also that a fraction of the sales in the foreign country will occur at this price if it is the lowest price between the domestic and foreign price. Firms set prices in the different countries, anticipating that there is going to be some arbitrage between countries. In this setting, parallel imports constitute a force that pushes towards the convergence of prices across countries to minimize the possibility of arbitrage.

We assume that firms do not internalize the effect of a price change on the probability of arbitrage (which depends on prices through the inclusive value of importing and buying locally). This assumption simplifies the derivation of the supply side and is reasonable since the effect of price changes on the probability of importing is negligible.

In particular, we consider a firm that sells cars in countries d and f. Let p_k^g denote the price of product k in country g and p^g the vector of prices in country g. Let $p^{min,g}$ denote the "minimum price vector" in country g, meaning that element k will be the price abroad if k is strictly cheaper abroad and will hold the domestic price otherwise. Further, let ϕ^g denote the probability of searching in country g. We can write the profit function as

$$\begin{aligned}
\pi =& \underbrace{(p_j^d - c_j^d)(1-\phi^d)q_j^d(p_j^d, p^d)}_{\text{d-consumers who do not search}} \\
&+ \underbrace{(p_j^d - c_j^d)\phi^d \mathbb{1}\{p_j^d \leq p_j^f\} q_j^d(p_j^d, p^{min,d})}_{\text{d-consumers who search but buy in d}} \\
&+ \underbrace{(p_j^d - c_j^d)\phi^f \mathbb{1}\{p_j^d < p_j^f\} q_j^f(p_j^d, p^{min,f})}_{\text{f-consumers who search and buy in d}} \\
&+ \underbrace{(p_j^f - c_j^f)(1-\phi^f)q_j^f(p_j^f, p^f)}_{\text{f-consumers who do not search}} \\
&+ \underbrace{(p_j^f - c_j^f)\phi^f \mathbb{1}\{p_j^f \leq p_j^d\} q_j^f(p_j^f, p^{min,f})}_{\text{f-consumers who search but buy in f}} \\
&+ \underbrace{(p_j^f - c_j^f)\phi^d \mathbb{1}\{p_j^f < p_j^d\} q_j^d(p_j^f, p^{min,d})}_{\text{d-consumers who search and buy in f}} \\
&+ \sum_{k \neq j} (p_k^d - c_k^d)(1-\phi^d)q_k^d(p_k^d, p^d)
\end{aligned}$$

$$
\begin{aligned}
&+\sum_{k\neq j}(p_k^d-c_k^d)\phi^d\mathbb{1}\{p_k^d\leq p_k^f\}q_k^d(p_k^d,p^{min,d})\\
&+\sum_{k\neq j}(p_k^d-c_k^d)\phi^f\mathbb{1}\{p_k^d< p_k^f\}q_k^f(p_k^d,p^{min,f})\\
&+\sum_{k\neq j}(p_k^f-c_k^f)(1-\phi^f)q_k^f(p_k^f,p^f)\\
&+\sum_{k\neq j}(p_k^f-c_k^f)\phi^f\mathbb{1}\{p_k^f\leq p_k^d\}q_k^f(p_k^f,p^{min,f})\\
&+\sum_{k\neq j}(p_k^f-c_k^f)\phi^d\mathbb{1}\{p_k^f< p_k^d\}q_k^d(p_k^f,p^{min,d})
\end{aligned}
$$

The derivative of the profit function with respect to the price of product j is then

$$
\begin{aligned}
\frac{\partial\pi}{\partial p_j^d}=&(1-\phi^d)q_j^d(p_j^d,p^d)+(p_j^d-c_j^d)(1-\phi^d)\frac{\partial q_j^d(p_j^d,p^d)}{\partial p_j^d}\\
&+\phi^d\mathbb{1}\{p_j^d\leq p_j^f\}q_j^d(p_j^d,p^{min,d})+(p_j^d-c_j^d)\phi^d\mathbb{1}\{p_j^d\leq p_j^f\}\frac{\partial q_j^d(p_j^d,p^{min,d})}{\partial p_j^d}\\
&+\phi^f\mathbb{1}\{p_j^d< p_j^f\}q_j^f(p_j^d,p^{min,f})+(p_j^d-c_j^d)\phi^f\mathbb{1}\{p_j^d< p_j^f\}\frac{\partial q_j^f(p_j^d,p^{min,f})}{\partial p_j^d}\\
&+\sum_{k\neq j}(p_k^d-c_k^d)(1-\phi^d)\frac{\partial q_k^d(p_k^d,p^d)}{\partial p_j^d}\\
&+\sum_{k\neq j}(p_k^d-c_k^d)\phi^d\mathbb{1}\{p_k^d\leq p_k^f\}\mathbb{1}\{p_j^d\leq p_j^f\}\frac{\partial q_k^d(p_k^d,p^{min,d})}{\partial p_j^d}\\
&+\sum_{k\neq j}(p_k^d-c_k^d)\phi^f\mathbb{1}\{p_k^d< p_k^f\}\mathbb{1}\{p_j^d< p_j^f\}\frac{\partial q_k^f(p_k^d,p^{min,f})}{\partial p_j^d}\\
&+\sum_{k\neq j}(p_k^f-c_k^f)\phi^f\mathbb{1}\{p_k^f\leq p_k^d\}\mathbb{1}\{p_j^d< p_j^f\}\frac{\partial q_k^f(p_k^f,p^{min,f})}{\partial p_j^d}\\
&+\sum_{k\neq j}(p_k^f-c_k^f)\phi^d\mathbb{1}\{p_k^f< p_k^d\}\mathbb{1}\{p_j^d\leq p_j^f\}\frac{\partial q_k^d(p_k^f,p^{min,d})}{\partial p_j^d}
\end{aligned}
$$

To express the system of first order conditions in matrix notation, we define $\tilde{q}_j^d$ to be the quantity of product j that is sold at the markup of country d and is given by

$$
\tilde{q}_j^d=(1-\phi^d)q_j^d(p_j^d,p^d)+\phi^d\mathbb{1}\{p_j^d\leq p_j^f\}q_j^d(p_j^d,p^{min,d})+\phi^f\mathbb{1}\{p_j^d< p_j^f\}q_j^f(p_j^d,p^{min,f})
$$

Denote $\tilde{\boldsymbol{q}}^d$ the corresponding vector that stacks the quantities of all products sold at $d-$markups.

We collect the partial derivatives that pre-multiply the $d-$ and $f-$ markups, respectively, into matrices Ω^{dd} and Ω^{df}. Elements (j,j) and j,k of Ω^{dd} are given by

$$\Omega^{dd}(j,j) = (1-\phi^d)\frac{\partial q_j^d(p_j^d, p^d)}{\partial p_j} + \phi^d \mathbb{1}\{p_j^d \leq p_j^f\}\frac{\partial q_j^d(p_j^d, p^{min,d})}{\partial p_j} + \phi^f \mathbb{1}\{p_j^d < p_j^f\}\frac{\partial q_j^f(p_j^d, p^{min,f})}{\partial p_j}$$

$$\Omega^{dd}(j,k) = (1-\phi^d)\frac{\partial q_k^d(p_k^d, p^d)}{\partial p_j} + \phi^d \mathbb{1}\{p_k^d \leq p_k^f\}\mathbb{1}\{p_j^d \leq p_j^f\}\frac{\partial q_k^d(p_k^d, p^{min,d})}{\partial p_j}$$
$$+ \phi^f \mathbb{1}\{p_k^d < p_k^f\}\mathbb{1}\{p_j^d < p_j^f\}\frac{\partial q_k^f(p_k^d, p^{min,f})}{\partial p_j},$$

and element (j,k) of Ω^{df} is given by

$$\Omega^{df}(j,k) = \phi^f \mathbb{1}\{p_k^f \leq p_k^d\}\mathbb{1}\{p_k^d < p_k^f\}\frac{\partial q_k^f(p_k^f, p^{min,f})}{\partial p_j^d} + \phi^d \mathbb{1}\{p_k^f < p_k^d\}\mathbb{1}\{p_j^d \leq p_j^f\}\frac{\partial q_k^d(p_k^f, p^{min,d})}{\partial p_j^d}.$$

Finally, we collect the $d-$ and $f-$ markups into vectors $\boldsymbol{p}^d - \boldsymbol{c}^d$ and $\boldsymbol{p}^f - \boldsymbol{c}^f$.
Defining $\tilde{\boldsymbol{q}}^f$, Ω^{ff}, and Ω^{fd} analogously, we can express the system of first order conditions as

$$\begin{pmatrix} \tilde{\boldsymbol{q}}^d \\ \tilde{\boldsymbol{q}}^f \end{pmatrix} + \begin{pmatrix} \Omega^{dd} & \Omega^{df} \\ \Omega^{fd} & \Omega^{ff} \end{pmatrix} \begin{pmatrix} \boldsymbol{p}^d - \boldsymbol{c}^d \\ \boldsymbol{p}^f - \boldsymbol{c}^f \end{pmatrix} = 0$$

Inverting this system, we can back out the markups that are given by

$$\begin{pmatrix} \boldsymbol{p}^d - \boldsymbol{c}^d \\ \boldsymbol{p}^f - \boldsymbol{c}^f \end{pmatrix} = -\begin{pmatrix} \Omega^{dd} & \Omega^{df} \\ \Omega^{fd} & \Omega^{ff} \end{pmatrix}^{-1} \begin{pmatrix} \tilde{\boldsymbol{q}}^d \\ \tilde{\boldsymbol{q}}^f \end{pmatrix}$$

3.3 Identification

If the fraction of importers in each region was observed, identification of the demand model would be standard and would use the same argument as BLP (1995).

Instead, we rely on the following elements: (i) How the difference between the domestic price and the lowest foreign price is correlated with the market shares and the distance identifies the transportation cost.

(ii) The difference in the correlation between the market shares and the price difference for consumers with different demographic characteristics identify the parameters of the search cost function.

4 Estimation

The estimation method relies on the general method of moments. As is standard in the literature, we suppose that characteristics of products are exogenous and predetermined while prices are endogenous and likely to be correlated with unobserved characteristics.

Thus, we use instruments to construct our moment conditions:

$$E(Z\xi^r) = 0$$

As instruments we rely on differentiation IVs (Gandhi and Houde, 2019). Among other things, we also build differentiation IVs based on predicted price differences. We exclusively use exogenous product characteristics to predict these differences, ensuring the exogeneity of this instrument.

The results are summarized in Table 2.

Even though the coefficient on *price/income* is larger in absolute value for Germany, the price semi-elasticity is smaller in absolute value than in France. The price elasticities we estimate seem to be in the ballpark of previous studies. We also see that the search cost is lower in Germany, translating into a mean search probability that is more than twice as high. For other parameters we also see differences in valuation: French consumers are more averse to higher fuel cost, but not by much. The most important difference is the willingness to pay for Diesel cars, which is substantially higher in France (in fact, it is negative in Germany). Figures 2 and 3 plot the mean, minimum and maximum search probabilities in the different counties over time. In France, the mean search probability fluctuates throughout the sample period but is at similar levels in 2014 compared to 2005. In Germany, the mean search probability decreased from almost 70% to below 50%. It also became more dispersed over time.

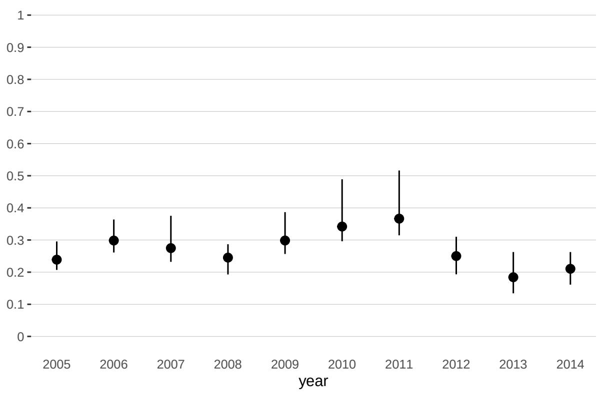

Figure 2: Search probability France

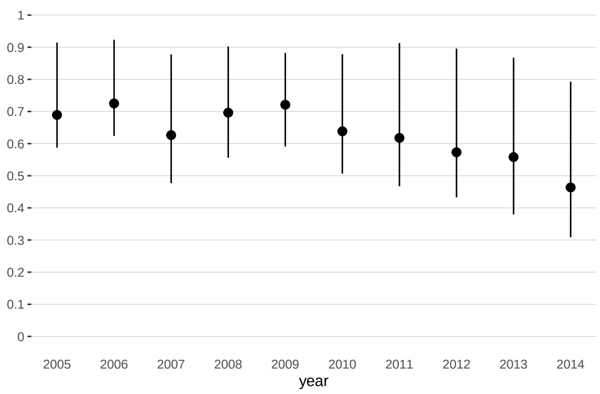

Figure 3: Search probability Germany

4.1 Supply

With demand estimates in hand, we can back out markups and marginal costs. In doing so, we use a simplified profit maximization problem in which we assume that firms to not internalize the effect of their price decisions on the search probability. Table 4.1 shows the results. We can see that on average, marginal costs in France exceed those in Germany by €4,000. Accordingly, markups are substantially higher in Germany, translating

Table 2: Results

Variable	France	Germany
Price		
Price/Income	-2.413	-3.560
	(0.104)	(0.320)
Search cost		
Intercept	-3.713	-6.074
	(0.337)	(0.161)
Mean utility		
Fuelcost/Income	-0.186	-0.364
	(0.012)	(0.016)
(Fuelcost/Income) x Density	-0.252	-0.125
	(0.016)	(0.013)
HP	2.089	0.627
	(0.043)	(0.020)
HP x Density	-0.103	0.316
	(0.057)	(0.019)
Weight	-0.240	0.000
	(0.064)	(0.000)
Weight x Density	0.280	0.000
	(0.060)	(0.000)
Diesel	1.245	-0.308
	(0.032)	(0.014)
Diesel x Density	-0.478	-0.100
	(0.043)	(0.014)
Footprint	0.558	0.482
	(0.025)	(0.014)
Footprint x Density	-0.027	0.031
	(0.020)	(0.007)
Search probability		
Mean	0.271	0.631
Median	0.268	0.643
Max	0.516	0.923
Min	0.134	0.309
Elasticity		
Mean	-5.080	-3.290

into a higher Lerner index. We can also see that our supply-side models predicts negative marginal costs for some products and unrealistically high marginal costs for other products. This hints at a lack of flexibility in the demand system.

Figures 4 and 5 present these findings graphically. On the right panel, we can see that the markup distributions barely overlap and exhibit a low variance.

To asses the factors driving marginal cost, we regress the implied marginal cost for

Table 3: Prices, marginal costs, markups

	France				Germany			
	Price	Marginal cost	Markup	Lerner index	Price	Marginal cost	Markup	Lerner index
Mean	29,685	21,543	8,142	0.3876	28,727	17,562	11,165	0.5265
Min	6,028	-3,449	6,522	0.041	6,580	-4,685	7,004	0.0677
Max	177,868	170,580	14,345	1.4821	166,927	155,348	14,289	1.7099

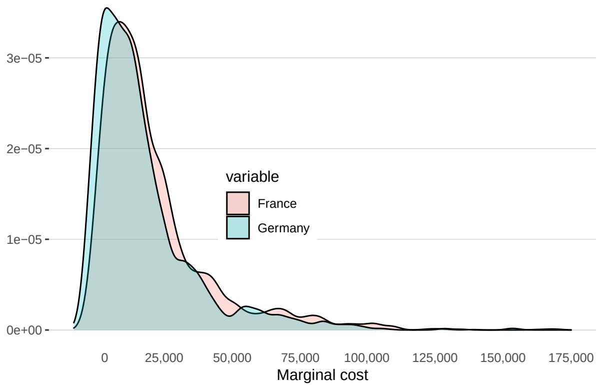

Figure 4: Distribution of marginal cost

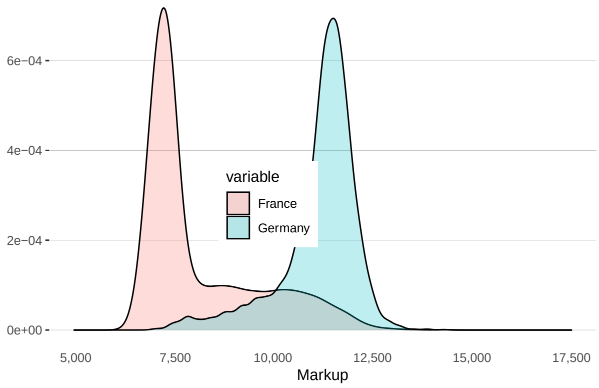

Figure 5: Distribution of markups

each country's products on cost shifters and fixed effects. The results are in Table 4. The largest difference across the two countries is the Diesel dummy. The point estimates suggest that producing a Diesel is around €400 more expensive to sell. It also seems like cars with a lower fuel cost are cheaper to sell in Germany. Overall, however, the differences are rather small and the main differences seem to lie in year-and model specific factors.

5 Counterfactuals

5.1 Procedure

We next turn to our counterfactual analysis. We consider three scenarios:

1. All taxes except value added taxes are removed

2. The French tax regime applies in both countries. This includes the rule that a rebate only applies when the car is bought domestically. VAT stays country-specific.

3. The German tax regime applies to both countries. VAT stays country-specific.

We use the following procedure to find the new price vector at the observed level of market integration:

1. We predict counterfactual prices assuming markets are completely separated. We extract the price vectors for France and Germany and fix the direction of price differences (determined through firm prices).

Table 4: Marginal cost regressions

	Dependent variable:	
	Marginal cost	
	France	Germany
	(1)	(2)
Intercept	0.039***	0.049***
	(0.007)	(0.005)
Fuel cost	1.636***	1.518***
	(0.037)	(0.025)
Horse Power	0.068	0.0002**
	(0.096)	(0.0001)
Weight	0.485***	0.472***
	(0.035)	(0.022)
Diesel	0.145***	0.188***
	(0.040)	(0.028)
Footprint	−0.037	−0.022
	(0.029)	(0.020)
2006	−0.056*	−0.052**
	(0.029)	(0.020)
2007	−0.183***	−0.159***
	(0.029)	(0.020)
2008	−0.077**	−0.046**
	(0.031)	(0.022)
2009	−0.110***	−0.103***
	(0.031)	(0.022)
2010	−0.198***	−0.169***
	(0.031)	(0.022)
2011	−0.262***	−0.272***
	(0.032)	(0.022)
2012	−0.214***	−0.253***
	(0.033)	(0.023)
2013	−0.131***	−0.221***
	(0.035)	(0.025)
Model FE	Yes	Yes
Observations	3,515	3,515
R^2	0.973	0.984
Adjusted R^2	0.970	0.983
Residual Std. Error	0.359	0.251
F Statistic	323.810***	557.422***
Note:	*p<0.1; **p<0.05; ***p<0.01	

2. We predict counterfactual prices at the current level of market integration and the assumed tax regime, imposing that the price differences found in step 1 be weakly satisfied.

To find new price vectors, we iterate on the first order conditions of firms. In addition, we also predict counterfactual prices assuming full integration for each assumed tax regime. In the case of full integration, the profit function becomes

$$\pi = \sum_{k \neq j} \left[(p_k - c_k^d) q_k^d(p) + (p_k - c_k^f) q_k^f(p) \right]$$

The first order condition is then

$$\boldsymbol{q}^d + \boldsymbol{q}^f + \Omega^d(\boldsymbol{p} - \boldsymbol{c}^d) + \Omega^f(\boldsymbol{p} - \boldsymbol{c}^f) = 0,$$

yielding

$$\boldsymbol{p} = (\Omega^d + \Omega^f)^{-1}(\Omega^d \boldsymbol{c}^d + \Omega^f \boldsymbol{c}^f + \boldsymbol{q}^d + \boldsymbol{q}^f)$$

5.2 Results

The results are presented in Table 5. The counterfactuals we run allow us to compare the effect of market integration at given taxation schemes as well as the effects of changes in taxation at given levels of market integration.

The effects of market integration

When comparing the first 3 columns, we can see that German consumers prefer the current level of integration to both full separation and full integration. In contrast, French consumers would prefer either extreme case and overall would be best off under full integration. The main driver behind this results is that full integration makes cars in France cheaper, which benefits all consumers and especially those who do not search. CO2 emissions would not be affected much by a change in the level of market integration. Under the current taxation scheme, CO2 emissions decrease slightly.
These results change when considering different taxation regimes. When all taxes are removed or German taxes imposed everywhere, French consumers in fact prefer the current level of integration. In these cases, fleet emissions also increase under full integration. This finding underscores that integration and environmental taxation interact to deliver ambiguous results regarding the environmental impact of integration.

The effects of environmental taxation

When comparing the middle column for each taxation regime, we can see first off that the environmental taxes imposed in France and Germany reduce fleet emissions by around 3.7 g/100km. We can also see that, if both countries used the French scheme, fleet emissions would be minimally lower whereas they would be larger if the German scheme was imposed everywhere. Whereas these effects are rather small in magnitude, the different taxation schemes lead to different import patterns that change the CO2 emissions of cars sold in the two countries. Fleet emissions of cars sold in Germany would be almost 3g/100km lower if German taxes were imposed everywhere. This is because under this scheme, many more French consumers buy cars in Germany. These cars tend to be more less polluting. On the other hand, fleet emissions of cars sold in France would go up.

In the rows “Profits DE firms” and “Profits FR firms”, we see the profits made by German (BMW, Daimler, and VW) and French (PSA and Renault) firms, respectively. We can see that, not surprisingly, German firms would prefer a world without any taxes. Interestingly, French firms prefer both the current tax scheme as well as a French-taxes-everywhere world to no taxes at all. The main reason is that many French-made cars apply for the rebate under the French feebate scheme, which boosts sales and/or may not be completely passed through. German car makers would also prefer a French-taxes-everywhere world to the current tax scheme. This may be due to the fact that some of their models also apply for the rebate.

The special case of French taxation

There is one special case which warrants further examination. Under the French feebate, imported cars do not apply for the rebate. However, cars that are subject to a fee need to pay this fee. In the discussion above, we introduced the French scheme with this clause. In Table 6, we present the results running a slightly modified counterfactual for the case of French taxes everywhere. In particular, we assume that in both countries, cars that are imported also apply for the rebate. We can see that both firm profits and consumer surplus is higher under the alternative scenario. This makes sense, as more products are subsidized under the alternative scenario. We can also see that fleet emissions would be lower by around .8 g per 100km.

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Table 5: Outcomes under different integration levels and taxation schemes

	Current taxes			No taxes			French taxes			German taxes		
Outcome	Separation	Current level	Integration	Separation	Current level	Integration	Separation	Current level	Integration	Separation	Current level	Integration
CS DE	4828.06	5020.79	4762.27	5663.61	6005.55	5578.10	5671.48	5885.19	5595.21	4828.06	5091.80	4762.27
CS FR	1910.71	1865.56	1911.25	1666.37	1820.69	1670.40	1910.71	1868.05	1911.25	1421.43	1534.56	1422.00
CS non-searchers DE	4828.06	2235.61	0.00	5663.61	2480.04	0.00	5671.48	1915.20	0.00	4828.06	2423.69	0.00
CS non-searchers FR	1910.71	1424.25	0.00	1666.37	878.15	0.00	1910.71	1532.64	0.00	1421.43	813.39	0.00
CS searchers DE	0.00	2785.19	4762.27	0.00	3525.51	5578.10	0.00	3969.99	5595.21	0.00	2668.11	4762.27
CS searchers FR	0.00	441.32	1911.25	0.00	942.53	1670.40	0.00	335.41	1911.25	0.00	721.17	1422.00
Profits	11673.41	11779.28	11582.48	12767.18	13175.03	12678.39	13145.48	12902.59	13069.68	10935.37	11257.29	10872.69
Profits DE	8753.25	7886.53	8728.78	10217.26	9417.10	10197.84	10225.31	8221.13	10207.23	8753.25	8239.21	8735.97
Profits FR	2920.17	3892.76	2853.70	2549.92	3757.92	2480.55	2920.17	4681.46	2862.45	2182.13	3018.08	2136.73
Profits DE firms	5773.74	5862.11	5719.07	6737.70	6957.42	6670.72	6733.32	6681.38	6677.22	5629.37	5796.53	5583.31
Profits FR firms	2245.00	2267.25	2243.78	1936.62	2169.29	1935.52	2375.07	2344.79	2373.75	1796.51	2002.89	1795.33
Firm prices DE	29234.66	28799.92	29358.15	29208.31	28540.79	29358.15	29227.48	29061.04	29358.15	29234.66	28641.67	29358.15
Firm prices FR	29529.51	30295.50	29358.15	29519.96	30329.44	29358.15	29529.51	30178.09	29358.15	29524.80	30348.99	29358.15
Final prices DE	37891.91	37374.57	38038.86	34757.89	33963.54	34936.20	36160.75	35962.69	36316.25	37891.91	37186.25	38038.86
Final prices FR	36815.46	37734.65	36609.83	35423.95	36395.33	35229.78	36815.46	37593.76	36609.83	38532.42	39521.45	38332.45
Firm sales DE	706755.00	661229.00	697368.00	825686.00	828352.00	813539.00	826261.00	673259.00	815520.00	706755.00	718732.00	697368.00
Firm sales FR	389500.00	453050.00	389566.00	340747.00	415958.00	341527.00	389500.00	563477.00	389566.00	291636.00	339186.00	291729.00
Registrations DE	706755.00	733802.00	697368.00	825686.00	873070.00	813539.00	826261.00	855726.00	815520.00	706755.00	743731.00	697368.00
Registrations FR	389500.00	380477.00	389566.00	340747.00	371241.00	341527.00	389500.00	381011.00	389566.00	291636.00	314187.00	291729.00
Search prob DE	0.00	0.46	1.00	0.00	0.51	1.00	0.00	0.58	1.00	0.00	0.43	1.00
Search prob FR	0.00	0.21	1.00	0.00	0.43	1.00	0.00	0.16	1.00	0.00	0.39	1.00
CO2	121.57	121.82	121.42	125.87	125.49	125.69	121.58	121.81	121.45	122.79	122.28	122.65
CO2 DE	126.93	126.37	126.76	129.85	127.19	129.57	126.18	125.56	126.04	126.93	123.78	126.76
CO2 FR	111.83	115.19	111.85	116.22	122.11	116.45	111.83	117.34	111.85	112.74	119.09	112.80
CO2 non-searchers DE	126.93	126.66	126.76	129.85	129.79	129.57	126.18	125.45	126.04	126.93	126.28	126.76
CO2 non-searchers FR	111.83	110.48	111.85	116.22	116.45	116.45	111.83	110.58	111.85	112.74	113.06	112.80
CO2 searchers DE	NaN	121.95	NaN	NaN	113.46	NaN	NaN	129.85	NaN	NaN	109.03	NaN
CO2 searchers FR	NaN	129.33	NaN	NaN	129.78	NaN	NaN	129.76	NaN	NaN	128.89	NaN
CO2 registered DE	126.93	127.07	126.76	129.85	129.79	129.57	126.18	126.45	126.04	126.93	126.74	126.76
CO2 registered FR	111.83	111.71	111.85	116.22	115.39	116.45	111.83	111.40	111.85	112.74	111.72	112.80

Table 6: Outcomes under different integration levels and taxation schemes

	French taxes- no rebate			**French taxes- with rebate**		
Outcome	Separation	Current level	Integration	Separation	Current level	Integration
CS DE	5671.48	5885.19	5595.21	5671.48	6141.29	5595.21
CS FR	1910.71	1868.05	1911.25	1910.71	2109.37	1911.25
CS non-searchers DE	5671.48	1915.20	0.00	5671.48	1501.85	0.00
CS non-searchers FR	1910.71	1532.64	0.00	1910.71	1002.75	0.00
CS searchers DE	0.00	3969.99	5595.21	0.00	4639.44	5595.21
CS searchers FR	0.00	335.41	1911.25	0.00	1106.62	1911.25
Profits	13145.48	12902.59	13069.68	13145.48	13538.51	13069.68
Profits DE	10225.31	8221.13	10207.23	10225.31	9105.02	10207.23
Profits FR	2920.17	4681.46	2862.45	2920.17	4433.49	2862.45
Profits DE firms	6733.32	6681.38	6677.22	6733.32	6903.96	6677.22
Profits FR firms	2375.07	2344.79	2373.75	2375.07	2705.75	2373.75
Firm prices DE	29227.48	29061.04	29358.15	29227.48	28696.80	29358.15
Firm prices FR	29529.51	30178.09	29358.15	29529.51	30232.97	29358.15
Final prices DE	36160.75	35962.69	36316.25	36160.75	35529.24	36316.25
Final prices FR	36815.46	37593.76	36609.83	36815.46	37659.61	36609.83
Firm sales DE	826261.00	673259.00	815520.00	826261.00	799229.00	815520.00
Firm sales FR	389500.00	563477.00	389566.00	389500.00	520616.00	389566.00
Registrations DE	826261.00	855726.00	815520.00	826261.00	891367.00	815520.00
Registrations FR	389500.00	381011.00	389566.00	389500.00	428478.00	389566.00
Search prob DE	0.00	0.58	1.00	0.00	0.68	1.00
Search prob FR	0.00	0.16	1.00	0.00	0.45	1.00
CO2	121.58	121.81	121.45	121.58	121.02	121.45
CO2 DE	126.18	125.56	126.04	126.18	121.98	126.04
CO2 FR	111.83	117.34	111.85	111.83	119.53	111.85
CO2 non-searchers DE	126.18	125.45	126.04	126.18	125.39	126.04
CO2 non-searchers FR	111.83	110.58	111.85	111.83	112.43	111.85
CO2 searchers DE	NaN	129.85	NaN	NaN	108.12	NaN
CO2 searchers FR	NaN	129.76	NaN	NaN	127.22	NaN
CO2 registered DE	126.18	126.45	126.04	126.18	125.91	126.04
CO2 registered FR	111.83	111.40	111.85	111.83	110.84	111.85