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Estimating the Price Overcharge from Cartelisation of the Irish Automobile Industry

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Abstract: Price coordination can be very harmful for consumers. Yet, even if a cartel is proved to exist, and successful in enforcement, how do we estimate damages or price overcharges to consumers? We build a structural model of the Irish automobile market that avails of a cross-section of new cars and jointly estimate demand and cost primitives. We use these estimates to quantify the role that price coordination could play in terms of pricing, profits and burden of taxation in three alternative regimes: All models of cars compete in price (Regime I); Only cars of different manufacturers compete in price (Regime II); Only cars of different importers compete in price (Regime III).

I INTRODUCTION

Economic theory tells us that in oligopolistic markets price coordination can lead to market power. In other words, consumers end up paying higher prices than they would in a more competitive market. Furthermore, if market power leads to more taxation in a market with monopolistic power, firms may find a certain optimal philanthropy in equilibrium, and absorb a bigger share

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of the tax burden. It is, therefore, also relevant to disentangle how much of the taxation is actually paid by consumers, known in the literature as "incidence of taxation". In this paper we look at the Irish automobile market to quantify changes in consumer welfare when price coordination and taxation interact under three alternative regimes: All models of cars compete in price (Regime I); Cars of different manufacturers compete in price (Regime II); Cars of different importers compete in price (Regime III). We do that by estimating a structural model of equilibrium in the Irish new automobile market based on Regime II, and undertake counterfactuals in equilibrium to compare with outcomes in Regimes I and III. In this way we can back out, for all three regimes, the following statistics: (i) profits earned by the industry, (ii) excessive pricing, and (iii) changes in the incidence of taxation.[1]

While we do compute the degree of overcharging by segment, caused by price coordination amongst dealers of the same manufacturers or importers, the presence of price coordination has to be proven in a court of law. We are just highlighting, given consumer and cost primitives, the possible returns to price coordination in this industry, and possible changes in the burden of *ad valorem* differentiated taxation that falls on the consumer as a result of industry cartelisation.

II DATA

We are well aware that the three regimes imply different vertical relations between Producers, Importers and Dealers. However our data and model do not let us disentangle how they share the profits; therefore our use of the word industry is inclusive of all three categories. Another restriction of our data is that we observe the list price, and there is no information on potential discounts available. This is not going to be a big issue, but once we compute the market power and the profits we have to be aware that a certain percentage of these calculations might be discounts. The data that we use in our analysis comes from two main sources:

- Volume data were provided by the Central Statistics Office, which collects the data from the revenue department for tax reasons. These data are also available from the SIMI (Body representing the Motoring Industry in Ireland).
- The price and model characteristics data were compiled from specialised press (mostly from "Car Buyer Guide").

[1] Structural models are used in Antitrust cases in the United States and are becoming increasingly used in Europe to evaluate the level of competition in specific markets.

We follow the industry classification of sub-markets and allocate the car models into the following seven segments:

1. Off Roads, SUV, Four by Four (Hyundai Santa Fe, ...).
2. City (Peugeot 106, Fiat Punto, ...).
3. Compact (Peugeot 206, Toyota Corolla, …).
4. Multi Purpose Vehicle (Opel Zafira, ...).
5. Executive (Audi A4, ...).
6. Medium (Ford Mondeo, ...).
7. Convertible & Coupe (Megane Coupe, ...).

Detailed information on the car characteristics and unit sales for the top five sellers in each segment is documented in Table 1.

Our data on the new car market in Ireland, in 2003, shows purchases of 133,000 automobiles grossing 3.3 billion euro in sales. Even though we do not have all the car sales we are very close to having the full population. The top four company concentration index (C4) shows the Irish automobile market not to be particularly concentrated. In Tables 2 and 3 we see the top four companies account for 46 per cent of the market when measured in unit sales, and 40 per cent when measured in terms of turnover. Regarding the consolidation of importing power, Tables 2 and 3 display that the top four importers account for 57 per cent of the market when measured in unit sales, and 56 per cent when measured in terms of turnover. Conventional economic theory might interpret this as a signal that the industry is reasonably competitive in terms of import and sales structure. However, this can be misleading if products are not homogeneous, as in the case of automobiles. Tables 2 and 3 are also informative on each segment market share and on the C4 indices within each segment. Unit sales and turnover are much more concentrated into the top four companies, or top four importers at the segment level. For companies, on average, we see a C4 of 64 per cent in unit sales and 65 per cent in turnover; for importers, on average, we see a C4 of 70 per cent in unit sales and 71 per cent in turnover. These figures suggest that cartelisation by companies or importers could lead to substantial increases in market power. The next section outlines the necessary econometric model to test this more thoroughly.

III THE MODEL

In differentiated products industries, firms' market shares are no longer a good approximation of their ability to mark-up prices over costs (see Mariuzzo *et al.*, 2003). The market is now made up of a number of products that are

Table1: *Top Five Cars in Each Segment*

Segment	*Unit Sales*	*Manufacturer*	*Range*	*Body*	*Essence*	*List Price*	*Engine cc*	*Length*	*Width*	*Height*	*Weight*	*MPG*	*Horse Power*	*Max spd*	*Accelera-tion*	*Doors*
4x4	234	SUZUKI	GRAND VITARA	SUV	essence	22,775	1590	476	178	174	1735	35.3	93	90	13.3	3
4x4	259	HONDA	CR-V	SUV	essence	36,960	1998	453	175	167	1515	31	148	110	10.2	5
4x4	415	TOYOTA	RAV JEEP	SUV	essence	32,005	1794	426	178	171	1490	38	125	109	12.3	5
4x4	496	HYUNDAI	SANTA FE	SUV	essence	29,245	1975	450	182	173	1718	29.6	132	108	11.5	5
4x4	683	HYUNDAI	SANTA FE	SUV	diesel	34,245	1991	450	182	173	1718	37.5	115	103	14.9	5
city	1528	VOLKSWAGEN	POLO	Hatch-Back	essence	15,910	1198	389	165	146	1660	47.9	55	94	17.5	5
city	1883	TOYOTA	YARIS	Hatch-Back	essence	14,995	998	364	166	150	1000	50.4	68	96	14.1	5
city	2070	FIAT	PUNTO	Hatch-Back	essence	13,495	1242	386	166	148	1075	49.6	60	96	14.3	5
city	2188	FORD	FIESTA	Hatch-Back	essence	15,945	1388	391	168	143	1152	44.1	79	101	13	5
city	3288	NISSAN	MICRA	Hatch-Back	essence	14,990	988	371	166	154	1046	49	65	96	15.7	5
compact	1560	FORD	FOCUS	Saloon	diesel	22,410	1753	438	170	143	1328	52.3	90	112	12.4	4
compact	1660	FORD	FOCUS	Hatch-Back	essence	19,515	1388	417	170	143	1318	44.1	75	106	14.1	5
compact	1913	TOYOTA	COROLLA	Hatch-Back	essence	19,565	1398	418	171	147	1345	42.2	97	115	12	5
compact	3567	TOYOTA	COROLLA	Saloon	essence	19,680	1390	438	171	147	1295	42.2	97	115	12	4
compact	3731	NISSAN	ALMERA	Saloon	essence	19,295	1498	443	170	144	1306	42.8	90	107	13.8	4
mpv	291	MITSUBISHI	SPACESTAR	medium mpv	essence	18,665	1299	405	171	155	1265	41.5	86	105	13.5	5
mpv	333	HYUNDAI	TRAJET	mpv	diesel	31,750	1997	469	184	176	1909	37.2	111	106	13.1	5
mpv	374	HYUNDAI	TRAJET	mpv	essence	28,250	1997	469	184	176	1909	30.4	136	119	12.9	5
mpv	411	OPEL	ZAFIRA	medium mpv	essence	25,355	1598	431	174	163	1525	34	99	108	13.5	5
mpv	614	OPEL	ZAFIRA	medium mpv	essence	27,275	1598	431	174	163	1525	34	99	108	13.5	5
exec	440	BMW	300 SERIES	Saloon	diesel	35,700	1796	448	175	141	1630	35.8	116	125	12.2	4
exec	447	VOLVO	S40	Saloon	essence	26,820	1783	446	177	145	1426	40.9	122	124	10.5	4
exec	503	AUDI	A4	Saloon	diesel	38,600	1896	454	177	142	1611	51.4	130	122	11.3	4
exec	794	MERCEDES-BENZ	C CLASS	Saloon	essence	39,575	1796	461	174	142	1635	30.1	122	120	11.6	4
exec	1248	MERCEDES-BENZ	E CLASS	Saloon	essence	49,880	1998	481	182	145	1835	33.6	163	145	13	4
medium	887	NISSAN	PRIMERA	Saloon	essence	23,895	1596	456	176	148	1494	39.2	109	115	12.6	4
medium	895	VOLKSWAGEN	PASSAT	Saloon	diesel	29,855	1896	470	174	146	1597	52.3	100	119	11.3	4
medium	1103	VOLKSWAGEN	PASSAT	Saloon	diesel	28,220	1896	470	174	146	1597	52.3	100	119	11.3	4
medium	1594	TOYOTA	AVENSIS	Saloon	essence	25,180	1598	463	176	148	1450	39.1	110	119	12	4
medium	1692	TOYOTA	AVENSIS	Saloon	essence	24,250	1598	463	176	148	1450	39.1	110	119	12	4
cv&coupe	50	MERCEDES-BENZ	CLK CLASS	Sports / coupe non c	essence	62,150	2397	463	174	141	1715	26.3	170	147	8.2	2
cv&coupe	54	MERCEDES-BENZ	SL CLASS	Sports / coupe non c	essence	123,100	3724	453	181	129	1955	22.4	306	155	6.3	2
cv&coupe	99	HYUNDAI	COUPE	Sports / coupe non c	essence	28,575	1998	439	176	133	1335	31.7	139	125	8.6	3
cv&coupe	367	MERCEDES-BENZ	CLK CLASS	Sports / coupe non c	essence	54,300	1996	463	174	141	1715	33	163	143	12.5	2
cv&coupe	591	HYUNDAI	COUPE	Sports / coupe non c	essence	24,745	1599	439	176	133	1335	36.7	116	120	11.2	3

Table 2: *Top Four-Companies/Importers Concentration Index*

Market	*Unit Sales* *133,000*	*% C4 Companies* *46*	*% C4 Importers* *57*
Segment	*% of Unit Sales*	*% Within Segment* *C4 Companies*	*% Within Segment* *C4 Importers*
Off Roads, SUV, 4X4	5	55	55
City (Small) Cars	28	48	54
Compact (Medium) Cars	31	61	64
Multi Purpose Vehicles	5	56	56
Executive Cars	10	80	96
Medium (Large) Cars	20	58	74
Convertible & Coupe	1	88	93
Average		**64**	**70**

Table 3: *Top Four-Companies/Importers Concentration Index*

Market	*Turnover* *3.3 Billion*	*% C4 Companies* *40*	*% C4 Importers* *56*
Segment	*% of Turnover*	*% Within Segment* *C4 Companies*	*% Within Segment* *C4 Importers*
Off Roads, SUV, 4X4	8	53	53
City (Small) Cars	18	50	56
Compact (Medium) Cars	26	61	65
Multi Purpose Vehicles	5	58	58
Executive Cars	18	86	96
Medium (Large) Cars	22	59	74
Convertible & Coupe	3	87	92
Average		**65**	**71**

differentiated in their attributes. While consumers directly benefit from an increase in product variety (products get closer to their preferences), firms can now charge higher prices above their marginal costs by reducing the underlying level of competition in the market. In addition, firms (car makers) by producing various (differentiated) products, or makes of cars, can benefit from the ability to internalise cross-price effects in their optimal pricing decisions. In this environment the competitive constraint on pricing is determined by the degree of substitutability across the cars portfolios held by the car makers in the market. If price internalisation gives rise to monopolistic (market) power, we can imagine this effect to be even more intense if control of pricing is extended to importers that regulate sets of multi-product car makers. Another interesting effect is that caused by the interaction between price coordination and taxation. Price coordination may lead firms to absorb a bigger part of the taxation in an equilibrium framework and constrain price increases to some degree. We need to estimate changes in the incidence of taxation as the industry is assumed to cartelise.

The question now arises as to how we might map this complexity of multi-product firms, operating over different segments, into market power? We next introduce a structural approach that backs out the relevant information for each model of car, by simultaneously estimating a demand and pricing (supply) system for differentiated products in an environment where there is *ad valorem* differentiated taxation.

3.1 The Demand Equation

In order to evaluate market power with differentiated products and multi-product firms, it is necessary to estimate the degree of substitutability between the various products (cars) in the market. However, estimating demand for differentiated products has a dimensionality problem. A linear demand system for J products would ask for J^2 price parameters to estimate. One must therefore place some structure on the estimation.

A number of alternative demand specifications have been developed to deal with this dimensionality problem by reducing the dimensionality space. Representative consumer choice models include the distance metric model (Pinske, Slade and Brett, 2002; Pinske and Slade, 2004), or the multi-stage budgeting model (Hausman, Leonard and Zona, 1994).

A more realistic alternative is one that accounts for consumer heterogeneity. The discrete choice literature fulfils this requirement. Consumers chose the product that maximises their utility. Among the product choice is the possibility of buying nothing (outside option). This branch of literature includes the vertical model (Bresnahan, 1987), the logit or nested logit models (Berry, 1994), or a random coefficient model (Berry, Levinsohn and Pakes, 1995).

The vertical model is the simplest specification of demand used in this framework. Pioneering work by Bresnahan (1987) estimated competitive conduct for the differentiated automobile industry using a vertical model. This assumes that products compete only with the good located on either side of it in product space, and that all characteristics of the product are observed (no unobservable characteristic modelled).[2]

[2] As a result, cross-price elasticities for a product *j* are defined only with respect to neighbouring products.

Generalisations of the demand function can yield more reasonable properties, and thus allow for richer estimation of demand systems. In this paper we present the logit and nested logit model of demand, but for reasons that will be clear below we only estimate the nested logit version.[3]

Berry (1994) develops an approach to estimating differentiated demand systems to (i) allow for more flexible substitution patterns, and (ii) to correct for price endogeneity, since one does not observe all product characteristics. The logit model defines the utility for individual *i* consuming product *j* as the mean quality of product *j* plus idiosyncratic consumer tastes

$$U_{ij} = x_j\beta - \alpha p_j + \xi_j + \varepsilon_{ij}, \tag{1}$$

where x_j is a vector of observed product characteristics (cubic capacity, miles per litre, etc.), p_j is the price of product *j,* and ξ_j is a vector of unobservable (to the econometrician) demand characteristics.[4]

The variation in consumer tastes enters only through ε_{ij}, consumer *i*'s utility specific to product *j*, which is assumed to be an independently and identically distributed extreme value (over both products and individuals), leading to the property of *Independence of Irrelevant Alternatives*.[5] The utility function (1) can be re-written as

$$U_{ij} = \delta_j + \varepsilon_{ij}, \tag{2}$$

where δ_j describes the mean utility associated to product *j*. The logit model is often used for its tractability, but the property of the *Independence of Irrelevant Alternatives* induces estimates of substitution effects that are often considered inappropriate.

[3] However, one may also specify a more general demand function to allow for greater variations in consumer substitution patterns and a richer estimation of demand systems, as in Berry, Levinsohn and Pakes (1995). This specification of demand allows different individuals to have different tastes for different product characteristics and, in addition, can allow for consumer heterogeneity in terms of their response to prices. The random coefficients are designed to capture variations in the substitution patterns. Although more realistic than the logit or nested logit model, the estimation procedure is not so straightforward, requiring both simulation and numerical methods.

[4] Notice that our ignorance of ξ_j is not shared by firms and consumers. This implies that the price equilibrium accounts for its effect.

[5] The fact that ε_{ij} is i.i.d. in logit models leads to the property of *Independence of Irrelevant Alternatives*, which means that the ratio of market share of any two goods does not depend on the characteristics of other goods in the market. This indicates that two goods with the same shares have the same cross-price elasticities with any other good.

The nested logit model (McFadden, 1978) is just a simple extension of the logit case, and allows for the fact that we have various segments or groups in the market (for example city, compact, etc).[6] Thus, the j products or products are partitioned into $G+1$ groups, with $g = \{0,1,\ldots,G\}$ where the outside good (0) is the only one present in group 0. It allows for correlations in the error terms for products within a group, where groups are exogenously specified. The utility of consumer i for product j is similar to (2), but this time is inclusive of an additional idiosyncratic term and parameter. The nested logit follows Berry (1994) and is written as

$$U_{ij} = \delta_j + \zeta_{ig} + (1 - \sigma)\varepsilon_{ij} \,. \tag{3}$$

For consumer i, ζ_{ig} is utility common to all products within a group g and has a distribution function that depends on σ, with $0 \le \sigma < 1$. Higher values of σ indicate greater substitutability of products within groups. As the parameter σ approaches one, the within group correlation of utility levels across products goes to one (products within groups are perfect substitutes). As σ tends to zero, so too does the within group correlation.[7]

As shown in Berry (1994), from the defined utility function in equation (1), or more generally in (3), and with proper assumptions of the idiosyncratic term(s), we can derive the product market shares, which depend upon the unknown parameter vector δ_j. We can treat these mean utility levels as known non-linear transformations of market shares such that δ_j can map into a linear demand equation. We only present the demand relation for the nested logit model, as the logit version would simply set $\sigma = 0$. Therefore the resulting linear demand relation is written as

$$\ln(s_j) - \ln(s_0) = x_j\beta - \alpha p_j + \sigma \ln(s_{j/g}) + \xi_j \,, \tag{4}$$

where s_j is product j's share of the entire market (inside plus outside goods total), s_0 is the outside goods share of the entire market,[8] $s_{j/g}$ is product j's share of the group g to which it belongs, and ξ_j is an unobserved (to the econometrician) product characteristic that is assumed to be mean

[6] Individual variability now enters through the predetermined segmentation of the market, as well as through the error term which is still i.i.d. Thus we have *Independence of Irrelevant Nested Alternatives.*

[7] When $\sigma = 0$ this reduces to the ordinary logit model, where substitution possibilities are completely symmetric, for example as when all products belong to the same group.

[8] In our data we define the inside market to satisfy 89 per cent of possible consumers (those aged 18-65). This is a way to proxy for a purchase in a lifetime.

independent of *x*.[9] Since prices and the within group share are endogenous variables in equation (4), they must be instrumented and the instruments need to vary by product.

The corresponding nested logit own-price and cross-price elasticities are given in equations (5) and (6) respectively,

$$\varepsilon_{jj} = \alpha p_j \left[s_j - \frac{1}{1-\sigma} + \frac{\sigma}{1-\sigma} \mathrm{s}_{\mathrm{j/g}} \right] \tag{5}$$

$$\varepsilon_{jk} = \begin{cases} \alpha p_k \left[s_k + \dfrac{\sigma}{1-\sigma} s_{k/g} \right] & \text{if } k \neq j, \{j,k\} \in g \\ & \text{if } \alpha p_k s_k,\ j \in g, k \notin g \end{cases} \tag{6}$$

It is important to note that the elasticities here refer to the percentage change in market shares in response to a percentage change in price.[10] The within group correlation of utility levels, σ, and market share within the group *g*, $s_{j/g}$, are important determinants of the own-price elasticity and the cross-price elasticity with respect to other products within the same group. The cross-price elasticity between *j* and another product *k* located in a different group *g* is independent of *j*.[11]

In order to define the primitives of the demand function, or the own- and cross-price demand elasiticities for each product *j*, we derive estimates of α and σ from our demand equation (4). Using these demand side primitives, via an equilibrium pricing system of equations to be defined, we can back out the price-cost mark-up (Lerner Index) for each product *j*. Before considering the supply side and the Lerner Index for each product we describe the *ad valorem* differentiated taxation.

3.2 Ad Valorem Differentiated Taxation

One peculiarity of the Irish new automobile market is its high taxation. To each new automobile wholesale price or net price, p_j^n, we add a 21 per cent VAT, and on the top of that (raising the issue of double taxation) the vehicle

[9] Inverting the market share function to yield equation (4) allows one to estimate demand parameters without the need for assumptions on either the parametric distribution of the unobservables ξ_j, or on the actual process that generates prices (Berry, 1994).

[10] In the next section we will distinguish between prices and net prices. In terms of elasticities results do not differ: $\varepsilon = \varepsilon^n$.

[11] The number of elasticities that we compute is equal to the square of the number of automobiles. This translates in our data into a number that exceeds one million.

registration tax (VRT), whose percentages depend on each automobile cubic capacity (cc) in the following way:

- 22.5 per cent for cc ≤ 1400;
- 25 per cent for 1400 < cc ≤ 1900;
- 30 per cent for cc > 1900.

We assume firms to compete in net prices given the tax rates, τ chosen by the government. Given that the tax rates are related to the cubic capacity of the car, they are product-specific, τ_j and the price paid by consumers for each model is,

$$p_j = p_j^n \, (1 + \tau_j). \tag{7}$$

Considering the role of taxation, it becomes important to disentangle how much of it is paid by consumers and how much is absorbed by firms. In other words we have to compute the incidence of taxation. This requires estimating a structural model, using its primitives to compute the incidence of taxation. We can only see the true impact of price coordination on consumers once we account for the incidence of taxation in the new equilibrium. The next section presents the supply side relations and sheds more light on the role of taxation.

3.3 The Supply Function

A fully structural approach to estimating market power requires specifying the marginal cost function to be estimated. We align ourselves with the literature and assume a log-linear marginal cost function

$$\ln c_j = w_j \gamma + \omega_j, \tag{8}$$

where $\omega_j \gamma$ is a vector of observed product characteristics that determine manufacturing costs, and ω_j is a vector of product characteristics that are unobservable to the econometrician.

Multi-model car makers maximise,

$$\max_{p_j^n} \sum_{l \in J_f} \left(p_l^n - c_l\right) s_l \left(p_1, \ldots, p_j, \ldots, p_J\right) N, \qquad \left\{j, l\right\} \in J_f, \tag{9}$$

where J_f is the set of models produced by firm $f \in F$, N is the number of consumers in the economy, and s_l is model l's market share.

For simplicity, assume single-product price setting firms ($J_f = j = l$). Given marginal costs c_j, the first order profit maximising condition for the nested logit implies a Lerner index per car model as follows,

$$\frac{p_j^n - c_j}{p_j^n} = \frac{1}{p_j^n\left(1+\tau_j\right)}\left[\frac{1-\sigma}{\alpha}\Big/\left(1-\sigma s_{j/g}-\left(1-\sigma\right)s_j\right)\right] \tag{10}$$

The mark-up of list price on cost depends upon the substitution parameter σ and within group share $s_{j/g}$. The higher is σ, the greater weight attached to within group product share. The bigger the within group product share, the higher will be the product price-cost mark-up. Thus we observe a positive relationship between size and market power within segments. If $\sigma = 0$, in the case that there is no segmentation, we have an ordinary logit result, such that the mark-up depends only on product share, s_j, and not the within group share. Besides that, taxation plays a direct and indirect role. Its direct role is clear from (10), a higher level of taxation reduces the car makers' market power. The indirect way is however more subtle and more interesting, it shows up via the equilibrium condition. The equilibrium net prices can partly absorb part of the taxation, depending on the underlying level of competition. Price coordination is a determinant force here. Our structural model attempts to disentangle this indirect role of taxation by computing net price-tax elasticities,

$$\mathbf{\Phi}^{\tau} = (\partial \mathbf{p}^n./\mathbf{p}^n)(\partial \boldsymbol{\tau}./\boldsymbol{\tau})', \tag{11}$$

where $\mathbf{p}^n$ and $\boldsymbol{\tau}$ are $J \times 1$ column vectors, and ./ denotes a division element by element. The matrix (11) is related to the incidence of taxation, *it*, in the following way

$$\mathbf{it} = \mathbf{e} + \mathbf{\Phi}^{\tau}\mathbf{e},$$

where $\mathbf{e}$ is a column vector of ones.

Let's now move back to the more realistic case of multi-product firms. As shown in (9), a multi-product firm maximises the sum of profits accruing from its products, J_f. A firm/importer can internalise the cross-price effect on market share of the products it owns in the price setting of an individual product. The first order condition for each profit maximising product will have the general form,

$$s_j + \sum_{l \in J_f}\left(p_l^n - c_l\right)\frac{\partial s_j}{\partial p_l^n} = 0, \qquad \{j, l\} \in J_f \tag{12}$$

Given marginal costs c_j, assuming multi-product price setting firms, a multi-product Nash equilibrium is given by the system of J first order conditions. Using our demand primitives, the first order condition for the nested logit in equation (10) implies that product price equals marginal cost plus a mark-up, so we get estimates of a Lerner Index for each model j.[12] Thus, given the primitives of the demand system and price we will be able to calculate a marginal cost for each product.[13]

To write (12) in compact form we define the following matrix of partial derivatives as

$$\Delta \equiv \begin{cases} -\dfrac{\partial s_l}{\partial p_j^n} & \text{if models } \{j,l\} \in J_f, \\ 0 & \textit{Otherwise} \end{cases}$$

which accounts for the effect of the tax rates, τ. Hence the net pricing equation is,

$$\mathbf{p}^n = \mathbf{c} + \underbrace{\Delta^{-1}\mathbf{s}}_{\equiv \mathbf{markup}}$$

and the cost function (8) can be estimated using,

$$\ln\,(p_j^n - \text{markup}_j) = \mathbf{w}_j\gamma + \omega_j. \tag{13}$$

3.4 Estimation of the Structural Model

Berry (1994) proposes the simultaneous estimation of the nested logit demand equation in (4) with a specified marginal cost (supply) equation in (8). Demand and costs are jointly estimated using Generalised Method of Moments (GMM), where the set of instruments need to be jointly orthogonal to the unobservable for each equation. We separate out the linear parameters entering demand and supply and use a non-linear search method to estimate the non linear parameters (α, σ). We use a linear GMM, based on typical conditional independence, to estimate the linear parameters and a non-linear GMM to estimate the non-linear ones. Since we have an endogeneity issue in the simultaneous estimation of demand and supply, we need to instrument. Demand can be instrumented using cost shifters not present in the demand

[12] This assumes that a Nash equilibrium exists. This has been proven for a general discrete choice model and assuming single product firms (Caplin and Nalebuff (1991)), and for the nested logit model with multiproduct firms in the symmetric case (Anderson and de Palma (1992)).
[13] Aggregating these estimates over a firm's products gives an indicator of firm market power. This may be done by taking a strict average, median outcome, or a weighted (by product share of firm sales) average.

equation, while supply can be instrumented using demand shifters not in the cost equation. However, various alternatives have also been suggested.[14]

Employing a structural approach to estimating market power thus requires specifying both a demand and supply function, and estimating them jointly. A key advantage of this approach is the flexibility allowed in terms of undertaking various counterfactual exercises. For instance one could examine the effect that a removal of the price constraining components of firm ownership structures (through a change in product ownership or the merger of firms for example) would have for welfare, consumer and producer surpluses [see Ivaldi and Verboven, (2000), for the use of a model of demand (Nested Logit) and supply in the Volvo/Scania case].

The approach we use is based on the above literature which assumes that individuals choose a particular automobile based on some physical and non-physical characteristics. Examples of characteristics we control for in our estimates are: List price, performance, cubic capacity, miles per gallon, horse power, length, height, acceleration, diesel (versus petrol), and company dummies. The fact that we simultaneously estimate demand and supply tailors our results to possible policy evaluations on different pricing regimes and allows us to estimate the incidence of taxation. The latter requires upsetting the pricing equilibrium by inducing small percentage changes in the taxation of all cars, and then seeing how that affects new equilibrium net prices. Computation of new price equilibrium in the market requires the use of numerical techniques (see Mariuzzo and Walsh, 2009) for details. We use also our estimates to evaluate different pricing scenarios:

1. Regime I (competitive benchmark): the industry has 1169 models of cars; all compete in pricing.
2. Regime II: the industry consists of 36 companies that price coordinate within the portfolio of cars.[15]

[14] Berry (1994) and Berry, Levinsohn and Pakes (BLP) (1995) suggest rival product characteristics as instruments for own-price, since a product *j*'s price is affected by variations in the characteristics of competing products which are excluded from the utility function. This is not valid however, if rival characteristics enter the demand equation directly. Hausman and Taylor (1981) and Hausman, Leonard and Zona (1994) suggest prices in one segment can be used as instruments for prices in another, allowing for firm and segment fixed effects. The prices of a firm's products in other segments, after the elimination of segment and firm effects, are driven by common underlying costs correlated with product price, but uncorrelated with the disturbances in the product demand equations. A problem may arise however, if prices in other segments are correlated with unobserved product characteristics. One must test the validity of instruments used to ensure that they are uncorrelated with the error. This may be done by assessing the correlation between instruments and residuals, taking into account the fact that the residuals are estimates of errors.

[15] Similarly, the dealers could fix the maximum discounts as a part of pricing.

3. Regime III: the industry has 26 importers. We use information on the distribution of some producers that share the same distributors (O'Flaterty, Armalou, Convest, Others) which might lead to further price internalisations.

IV RESULTS

We estimate the parameters of our demand and supply and compute for each car model (product) the level of market power and profits. In Table 4 we present the results from the estimation of the demand and cost functions outlined in equations (4) and (8), respectively. The key parameters in demand are α and σ. Having these parameters we can calculate the matrix of own- and cross-price elasticities as given in equations (5) and (6), respectively. In Table 5 we weight these by market shares and average by segment. The sum of the cross-price elasticities reported in the table is computed in the following way. For each car we sum the cross-price elasticities induced by a percentage increase in the price of all other cars sold in the market. That gives us a

Table 4: *GMM Estimation*

Demand System	*Regime II*
Segment correlation (σ)	0.807
	(0.180)
Price effect (α)	2.225
	(0.175)
Product Characteristics	Yes
Dummy companies	Yes
Pseudo R^2 Demand	0.903
Marginal Cost System	
Product Characteristics	Yes
Dummy Companies	Yes
Dummy Segment	Yes
Pseudo R^2 "Supply"	0.819
GMM Function	0.151
Observations	1,168

Standard errors in parenthesis.
Physical characteristics used in demand: Miles per Litre, Length, Height, Acceleration, Diesel, Cubic Capacity. Physical characteristics used in "supply": Miles per Litre, Horse Power, Diesel, Cubic Capacity.
Endogenous variables in demand and pricing equation: p_j and $\ln s_{j/g}$. BLP instruments: Average Characteristics of Products of the Same Firm; Average Characteristics of Products of Other Firms.

Table 5: *Weighted (by Market Shares) Average Elasticities from Regime II*

Segment	*Own-price Elasticities*	*Sum cross-price Elasticities*
Off Roads, SUV, 4X4	–4.62	4.19
City (Small) Cars	–1.71	1.86
Compact (Medium)Cars	–2.32	2.35
Multi Purpose Vehicles	–3.23	3.07
Executive Cars	–5.20	4.66
Medium (Large) Cars	–2.98	2.88
Convertible & Coupe	–5.07	4.47

percentage increase (models are substitutes) in its market share. Next we calculate a weighted average at the segment level. From Table 5, due to lower own- and cross-price effects, we see that there is less price competition in City, Compact and Medium segments.

In Table 6 we report the weighted average (weights are the market shares of each automobile) of price-cost margins in the market under our three pricing regimes. See clearly that internalisation of cross-price effects within companies, or within importers, can lead to substantial increases in mark-ups. If dealers gave discounts of 8 per cent, Regime I would still leave us with a price-cost margin of 34 per cent, which is well above the perfectly competitive case. Yet, price coordination within dealers belonging to the same company (across the entire industry) can drive the estimated price-cost margin up by 4 per cent (increase estimated profits by approximately €76 million). Price coordination within dealers belonging to the same importers (across the entire industry) can drive the estimated price-cost margin up by 6 per cent (increase estimated profits by approximately €123 million).

Table 6: *(Weighted by Market Shares) Price-Cost Margins (PCM) and Profits*

Regime	*PCM*	*Profits*
I: All Cars	0.42	790
II: Cars of Different Manufacturers	0.46	866
III: Cars of Different Importers	0.48	913

In column II of Table 7 we document the average (weighted by unit sales) list price of the cars within segments. In column III we report the average (weighted by unit sales) estimated price-cost margin assuming no price coordination in the industry. In columns IV and V we account for the estimated

Table 7: *Coordination Effects*

Segment	*Average Prices (Weighted by Market Shares)*	*Average (Weighted by Market Shares) Price-Costs Margins Under No Price Coordination*	*Average (Weighted by Market Shares) Price-Costs Margins; Price Increase Due to Price Coordination Between Cars of the Same Manufacturer*	*Average (Weighted by Market Shares) Price-Costs Margins; Price Increase Due to Price Coordination Between Cars of the Same Importer*
Off Roads, SUV, 4X4	41,327	0.26	0.27; 1,930	0.28; 1,989
City (Small) Cars	15,275	0.59	0.63; 3,710	0.64; 4,814
Compact (Medium)Cars	20,615	0.44	0.48; 4,043	0.49; 4,838
Multi-Purpose Vehicles	28,777	0.34	0.36; 2,746	0.37; 2,957
Executive Cars	46,088	0.21	0.25; 3,728	0.29; 8,605
Medium (Large) Cars	26,259	0.34	0.38; 3,401	0.42; 7,503
Convertible & Coupe	49,376	0.30	0.34; 4,320	0.36; 6,007

price-cost margins in the presence of price coordination between dealers of the same company and importers, respectively. We also give the estimated price increase that resulted from the presence of price coordination. For example, in executive cars, due to estimated price-cost margins increasing by 4 per cent in Regime II and 8 per cent in Regime III, consumers have paid 3,728 euros per car over the odds, when price coordination is a common practice by dealers selling car models belonging to a company/manufacturing line and 8,605 euros more when price coordination is a common practice by dealers selling car models belonging to a importer line.

However this potential price overcharge may not totally fall on the consumer. We still have to calculate whether there is a change in the incidence of taxation in presence of an *ad valorem* differentiated taxation. Table 8 exhibits, at the segment-level, the percentage of taxation covered by consumers under three alternative pricing regimes. Regime I, the most competitive, demonstrates a lower tendency for the industry to absorb taxation, and in the segment of Convertible & Coupe it actually generates an overshifting (consumers are asked to pay more than 100 per cent of taxation). If we take the average incidence of taxation in Regime II and subtract that in Regime I, we find a –4.44 per cent difference. Next if we combine the average taxation reported in column II with the average weighted price in the industry, and monetise the effect of taxation, we obtain a value of –800 euros. Consumers, on average, pay 800 euros less tax for each car in the presence of price coordination between companies. Such values are then documented at the segment level under price coordination in Regime I and II. The main message from Table 8 is that there is a tendency for the industry to absorb part of the taxation as price overcharging increases. This generosity softens when price coordination is dictated by importers rather than by companies.

Comparing Tables 7 and 8, we clearly see that the role of taxation has a tendency to reduce the negative impact of price coordination; however its effect is generally too modest. Only in the Convertible & Coupe segment is it large enough to offset the effect of price coordination.

Table 8: *Incidence of Taxation*

Segment	*Regime I*	*Regime II*	*Regime III*
Off Roads, SUV, 4X4	98.36	96.31	98.37
City (Small) Cars	92.08	88.77	90.25
Compact (Medium)Cars	96.82	89.68	91.77
Multi-Purpose Vehicles	94.36	95.73	94.67
Executive Cars	99.18	95.17	94.46
Medium (Large) Cars	93.73	91.08	89.83
Convertible & Coupe	108.90	84.52	81.85
Average	95.21	90.77	91.51

V CONCLUSIONS

The overall message is that returns from illegal price coordination could be high in this industry. Of course the presence of price coordination has to be proven in a court of law. We are just highlighting, given consumer and cost primitives, the possible returns to price coordination, or the potential damages to the consumers, which are clearly non-trivial. We provide policy makers with a methodology to compute the degree of price overcharging by car model caused by price coordination amongst dealers of the same manufacturer or even the same importer. In addition, we compute the possible changes in the burden of *ad valorem* differentiated taxation that may fall on the consumer in the presence of price overcharging. We find that the industry will take on more of the burden as price coordination increases throughout the industry. There is little evidence that this effect would dominate that of price coordination.

This kind of structural modeling can be used to investigate other important issues such as changes in the nature of taxation, mergers and a fall in consumer income. Changing the nature of taxation could imply moving away from taxing the engine size of cars, to taxing CO_2 emissions. One has to be aware that changing the nature of taxation can interact with the nature of imperfect competition and produce outcomes that would be unexpected in traditional models of competition.

REFERENCES

ANDERSON, S. P. and A. DE PALMA, 1992. "Multiproduct Firms: A Nested Logit Approach", *Journal of Industrial Economics*, Vol. 60, pp. 261-276.

BERRY, S. 1994. "Estimating Discrete-Choice Models of Product Differentiation", *RAND Journal of Economics*, Vol. 25, pp. 242-262.

BERRY, S., J. LEVINSOHN and A. PAKES, 1995. "Automobile Prices in Market Equilibrium", *Econometrica*, Vol. 63, pp. 841-890.

BRESNAHAN, T., 1987. "Competition and Collusion in the American Automobile Industry: The 1955 Price War", *Journal of Industrial Economics*, Vol. 35, pp. 457-482.

CAPLIN, A. and B. NALEBUFF, 1991. "Aggregation and Imperfect Competition: On the Existence of Equilibrium", *Econometrica*, Vol. 59, pp. 25-60.

HAUSMAN, J. and W. TAYLOR, 1981. "Panel and Unobservable Individual Effects", *Econometrica*, Vol. 49, pp. 1377-1398.

HAUSMAN, J., G. LEONARD and J. D. ZONA, 1994. "Competitive Analysis with Differentiated Products", *Annales D'Économie et de Statistique*, Vol. 34, pp. 159-180.

IVALDI, M. and F. VERBOVEN, 2005. "Quantifying the Effects from Horizontal Mergers in European Competition Policy", *International Journal of Industrial Organization*, Vol. 23, pp. 669-691.

MARIUZZO, F., P. P. WALSH and C. WHELAN, 2003. "Firm Size and Market Power in Carbonated Soft Drinks", *Review of Industrial Organization*, Vol. 23, pp. 283-299.

MARIUZZO, F., and P. P. WALSH, 2009. "Modelling the Incidence of Differentiated Taxation as an Outcome of Imperfect Competition", Mimeograph, University College Dublin.

MCFADDEN, D., 1978. *Modelling the Choice of Residential Location* in A. Kaelgvist *et al.* (eds.), *Spatial Interaction Theory and Planning Models*. Amsterdam: North-Holland.

PINKSE, J. and M. E. SLADE, 2004. "Mergers, Brand Competition, and the Price of a Pint", *European Economic Review*, Vol. 48, pp. 617-643.

PINKSE, J., M. E. SLADE, and C. BRETT, 2002. "Spatial Price Competition: A Semi-parametric Approach", *Econometrica*, Vol. 70, pp. 1111-1155.