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International Price Discrimination In the European Car Market: An Econometric Model of Oligopoly Behavior with Product Differentiation

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An econometric model of oligopoly behavior with product differentiation

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ABSTRACT: *I develop an econometric model of oligopoly with product differentiation to analyze international price discrimination by manufacturers in the European car market. Existing studies cannot formally identify cross-country differences in the cost of operating in the various countries from differences in markups. My study essentially obtains identification through data on market structure. In a unified framework, three sources of international price discrimination are considered: price elasticities, import quota regimes and collusion. The data reveal that the first two sources explain the high prices in France and Italy. The very high prices in the United Kingdom may follow either from high operating costs (e.g. due to systematically high dealer markups) or from a high degree of collusion among car manufacturers.*

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1. Introduction

Large differences in car prices have been a persistent phenomenon in the European Community. Although these differences have somewhat diminished during the past decade, they remain quite large, and they are not likely to disappear in the near future. Flam (1992) reports current differences - net of taxes - of up to 92 percent for the same car type. Mertens and Ginsburgh (1985) and Ginsburgh (1992) construct a quality-adjusted price index for the whole industry, and find that the general car price level in Belgium, France, Germany, Italy and the United Kingdom varies up to 30 percent. These observed large price differences indicate that considerable market segmentation in the European car market continues to exist, despite efforts by the Community to lower transport costs and other arbitrage costs associated with cross-border trade. Yet, given that it is still *feasible* for car producers to charge different prices in the various national markets, the question remains what makes these practices *desirable* from a profit-maximizing perspective. Do car producers face different costs of operating in the various markets? Or, alternatively, do firms charge different markups and engage in international price discrimination?

This paper develops a framework to empirically answer these questions. I adopt an oligopoly model with product differentiation and multi-product price-setting firms. The resulting equilibrium pricing equation constitutes the basic equation to be estimated, jointly with the demand equation. It reveals that the price of each car type in each market equals its marginal cost plus a markup over marginal cost. The markup depends on three factors: on the price elasticities as generated by the model of product differentiation, on the possible presence of an import quota against the firm selling the car type, and on the degree of collusive behavior. These three factors are at the same time then three possible sources for international price discrimination.

The specific model of product differentiation chosen is a version of the nested logit model. It starts from basic assumptions about consumer preferences: one on an individual consumer's indirect utility function, the other on the distribution of the parameters of this utility function across the total market. These assumptions generate plausible substitution patterns, allowing for a localized notion of market. These assumptions generate plausible substitution patterns, allowing for a localized notion of competition. Several observed physical characteristics, such as horsepower and size, enter the demand equation of each car type and may affect the price elasticities. The same physical characteristics may also affect marginal cost. An error term, representing unobserved (to the econometrician) car characteristics, enters both the pricing and the demand equation. Unfortunately, the error terms generally enter the equations in a nonlinear way. Moreover, in equilibrium, car sales and prices are correlated with the error terms. To resolve these estimation issues, I follow a two-step method recently proposed by Berry (1993) and applied to the American car market by Berry, Levinsohn and Pakes (1993). First, I transform the pricing and demand equation such that the error terms enter linearly. Second, I choose appropriate instrumental variables that are interacted with the error terms to estimate the equilibrium pricing equation, jointly with the transformed demand equation.

The paper assumes that the European car market is entirely segmented into its national markets. Formally speaking, the cross-price elasticity of demand for any domestically sold car is zero with respect to any car sold abroad. An assumption of prohibitive consumer arbitrage costs generates this outcome. Although this assumption is rather extreme, various regulations indicate that substantial arbitrage costs exist: the requirement of national approval of each new car type and of national registration, and especially the legally protected exclusive dealerships throughout the Community.

I have collected data on prices, sales and physical characteristics of all car types sold in 1990 in five European countries: Belgium, France, Germany, Italy and the United Kingdom. The data reveal that international price discrimination, as measured by cross-country differences in markups over marginal costs, accounts for an important part of the observed price differences in the European car market.

The results of the paper are encouraging and make advances on various fronts. First, the empirical results contribute to our knowledge of the European car market. In a unified framework, the possible sources of international price discrimination are considered: cross-country differences in price elasticities, in quota regimes and in collusive behavior. Studies of the European car market at the level of the individual product have been scarce. The few studies that are available only partially address some of the questions that are posed in this paper.[1]

Second, the theoretical model developed in this paper takes into account several complexities that have not been explicitly treated in Berry (1991). The incorporated complexities aim to conform to the peculiarities of the European car industry, while keeping the econometric methods computationally tractable. I will state the most important innovations here. (1) A nested logit model with multiple dimensions is developed to allow for plausible substitution parameters and a localized notion of competition in the European car market. (2) Price enters utility in a flexible way, with important implications for the implied price elasticities and markups. (3) The pricing behavior of multiproduct firms, rather than single product firms, is explicitly treated. (4) The possibility of collusive pricing behavior, as opposed to unilateral pricing behavior, is explicitly considered. Berry, Levinsohn and Pakes (1993) and Goldberg (1993) consider some of these complexities.[2] However, they do not derive a closed-form solution for the pricing and demand equations. As a result, their econometric methods become computationally less tractable, and the connection between the equilibrium equations and the empirical results becomes somewhat less transparent.

The paper is organized as follows. Section 2 presents the various characteristics of the national markets and establishes the existence of significant price differences in the European car market from the construction of a "hedonic" price index. Section 3 develops the oligopoly model with product differentiation that is taken to the data. Section 4 discusses the econometric methods and the data. Section 5 provides and interprets the empirical results. Conclusions and suggested extensions follow in section 6.

2. The structure of the European car market and the hedonic price index

Before developing and estimating a model of oligopoly behavior to systematically explain the observed price differences, it is useful to first have a look at the European car market using traditional approaches. Table I reveals several major differences across the various markets in 1990. Cost conditions seem to vary widely due to differences in the rates of taxation (14 percent in Germany, twice as high in France; special luxury taxes for large cars in Belgium and Italy), and due to differences in hourly wages (wages vary from 9.7 ECU/hour in the United Kingdom to 23.6 ECU/hour in Germany). In addition, the different levels of concentration and internationalization suggest different degrees of market power. Belgium has the lowest concentration indices, no domestic producer, and a high rate of Japanese penetration. The Belgian market thus seems relatively competitive; firms exercise only moderate market power over price. The other markets are all characterized by relatively large concentration indices, have major domestic producers, and limited Japanese penetration. Especially France and Italy seem subject to significantly reduced competition, according to traditional indicators.

Do price differences across the various markets reflect these differences in costs, concentration, and internationalization? To compare prices across the whole product-differentiated industry, a "hedonic" price index may be constructed. This is a price index that adjusts for product quality differences as measured by observed physical characteristics. Griliches (1971), for example, constructed such an index to study price changes over time in the American car market. More related to the present study, Mertens and Ginsburgh (1985) constructed a hedonic price index to compare quality-adjusted price differences across five European markets. To construct a hedonic price index, assume that the price of a car j in market m, p_{jm}, is a function of its observed physical characteristics, a vector w_{jm}. To conform to previous studies take the following functional form:

$$p_{jm} = e^{w_{jm}\gamma + \overline{\omega}_{jm}} \tag{1}$$

An error term $\overline{\omega}_{jm}$ captures the part of the price of car j in market m that cannot be attributed to the observed physical characteristics, w_{jm}. Assume $\overline{\omega}_{jm}$ can be decomposed into an error term specific to the market m in which it is sold but identical for all cars j, and an error term specific to both the market m and the car j. That is:

$$\overline{\omega}_{jm} = \omega_m + \omega_{jm} \quad (2)$$

Equations (1) and (2) constitute a fixed effects model. The parameters can be estimated with a simple ordinary least squares regression, using a dummy variable approach to estimate the market-specific fixed effects ω_m. The estimated fixed effects ω_m allow the construction of the hedonic price index mentioned above.

The estimation results for 1990 are summarized in table II. Prices used are list prices net of taxes and are converted to ECU's using the average market exchange rate in 1990. The fixed effects are estimated for the four markets France, Germany, Italy and the United Kingdom, relative to the fifth market Belgium. The vector of physical characteristics, w_{jm}, consists of two parts. First, there is a list of continuously measured, technical characteristics: horsepower, weight, width and height. Second, there is a list of dummy variables to identify possible characteristics specific to the car's country of origin. The estimated parameters are generally consistent with previous hedonic studies, in particular with Mertens and Ginsburgh's (1985) study for the same five countries. All technical characteristics have precisely estimated parameters of the expected sign, in both specifications. The country-of-origin dummies have similar qualitative effects as found by Mertens and Ginsburgh. Especially German cars are higher priced relative to "other", mainly Eastern European cars. An interaction dummy variable indicates that foreign firms do not generally charge lower prices than the domestic firms. Note that the country-of-origin effects are not inconsistent with the wage differences listed in Table I.

The estimated fixed effects show that prices in 1990 for cars with identical physical characteristics are significantly higher in Germany and especially Italy and the United Kingdom than in Belgium and France. The estimated fixed effects suggest the firms' ability to charge different prices for identical cars, as already emphasized by Mertens and Ginsburgh. Thus, there must be substantial arbitrage costs leading to a segmentation of the European car market into its various national markets. This finding is summarized in Table III, presenting the hedonic price index, constructed from the estimated fixed effects.[3]

It is tempting to relate the hedonic price index to the structure of the European car market discussed above. In Belgium, the low concentration and high international penetration suggest intense competition. Correspondingly, the price level is relatively low. The other markets are substantially more concentrated, and experience less competition from abroad. This is reflected in a higher price index for Germany and especially for Italy and the United Kingdom. The relatively low price level in France, despite its concentrated market structure, is puzzling. It may be the consequence of a lower cost of operating in this market, e.g. because of low dealer markups or a particular government policy. The fairly high price level in the United Kingdom, relative to France and Germany (with similar concentration and internationalization indicators), is also puzzling. It may follow from a high cost of operating in this market.

Mertens and Ginsburgh (1985) made similar attempts to relate the hedonic price index to the structure of the European car market. However, they conclude their paper with the warning (p. 165):

> Clearly a careful study of the various price elasticities in these countries would help in interpreting the results, as would a deeper analysis of product differentiation. The paper does not examine whether price differentials originate in deliberate international producer discrimination policies, or whether this situation is the consequence of collusion among local dealers.

What is needed to more fully understand the observed price differences, is a model that explicitly considers the pricing decisions of the car manufacturers. For example, Rosen (1974) considers a perfectly competitive model with price taking firms and shows that the hedonic pricing equation results. Hence, one may interpret the hedonic pricing equation as a marginal cost function.[4] This would generate the following strict interpretation of the estimated fixed effects: they indicate that the marginal costs of operating were lowest in Belgium and France, and significantly higher in Germany and especially Italy and the United Kingdom. This interpretation of observed price differences is theoretically consistent, and indeed, in a recent study Kirman and Schueller (1990) argue that substantial cost differences between countries do exist. However, an explanation that is solely based on cost differences is at least suspect. The cross-country differences in concentration and internationalization emphasized above suggest that firms may be charging different markups over marginal costs, engaging in international price discrimination. To consider this possibility, a model of oligopoly behavior is required. The next section develops such a model, covering the competitive interpretation of the hedonic pricing equation as a special case. This allows us to empirically investigate whether the data support a pure cost-side interpretation of the observed price differences in the Community, or whether, in addition, international price discrimination is present.

3. An oligopoly model for the European car market

This section develops an econometrically tractable model of oligopoly behavior that captures the essential characteristics of the European car market. The model makes it possible to investigate whether the observed cross-country price differences are due to systematic differences in the cost of operating or due to differences in markups. To the extent that differences in markups are important, it can be said that international price discrimination is present. The model with its extensions allows for three causes of cross-country differences in markups: (1) differences in price elasticities due to product differentiation, (2) differences in quota regimes and (3) differences in the degree of collusive behavior.

The first subsection develops the car types' equilibrium pricing equation, and shows how the price of each car can be decomposed into its marginal cost and a markup over marginal cost. The second subsection discusses the nature of product differentiation and the implied price elasticities, and their role in the equilibrium markups. The third and fourth subsections introduce quota constraints and collusive behavior, and their respective roles in the markups.

3.1. Pricing

There are F multiproduct car manufacturers operating in five national markets. In a market m a firm f produces K_{fm} car types, with $J_m = \Sigma_f K_f$, the total number of car types in the market m. Firm f's profit in market m is:

$$\Pi_{fm} = \sum_{k=1}^{K_{fm}} \left[\frac{p_{km}}{1+d_m} - mc_{km} \right] \cdot q_{km}(p_{1m}, p_{2m}, \ldots, p_{Jm}) \tag{3}$$

where mc_{km} denotes car type k's marginal cost in market m, and q_{km} denotes aggregate demand for car type k in market m. It is assumed that q_{km} is a function of the car type's own price and of the price of its competitors sold in the *same* market. The price of car types sold in other markets does not enter q_{km}. This is based on the assumption of prohibitive arbitrage costs to consumers, as will be shown in the next subsection.

The variable d_m, common to all car types sold in the same market, captures the percentage deviation of the list price p_{km} from the actual price received by the firm. Assume that d_m consists of an observable and an unobservable (to the econometrician) component, i.e.

$$1 + d_m = (1 + t_m) \cdot (1 + \tau_m) \tag{4}$$

The observable component t_m is the tax rate imposed by the national government. The unobservable component, τ_m, includes a variety of elements such as market-average dealer markups,[5] errors in measured tax rates or unmeasured temporary exchange rate fluctuations.

Assuming each firm f in market m sets the price of every car it markets to maximize profits, the following J_m first-order conditions, for $j=1,\ldots,K_{fm}$ and $f=1,\ldots,F$, hold in each market m:

$$\sum_{k=1}^{K_{fm}} \left[\frac{p_{km}}{1+d_m} - mc_{km} \right] \cdot \frac{\partial q_{km}(p_{1m}, p_{2m}, \ldots, p_{Jm})}{\partial p_{jm}} + q_{jm}(p_{jm}, p_{2m}, \ldots, p_{Jm}) \cdot \frac{1}{1+d_m} = 0 \tag{5}$$

Taken together, these J_m first-order conditions constitute a Bertrand-Nash equilibrium. Defining $\Delta_{jkm} = -\partial q_{km}/\partial p_{jm}$ if k and j are produced by the same firm, and $\Delta_{jkm}=0$ otherwise, write the first-order conditions that hold in market m in vector notation:

$$- \Delta_m \cdot \left[\frac{1}{1+d_m} \cdot p_m - mc_m \right] + \frac{1}{1+d_m} \cdot q_m = 0 \tag{6}$$

where Δ_m is a J by J matrix, and p_m, mc_m and q_m are J by 1 matrices, and d_m remains the scalar defined above. Defining Δ_m^{-1} as the inverse J by J matrix of Δ_m, we get:

$$\frac{1}{1+d_m} \cdot p_m = mc_m + \frac{1}{1+d_m} \cdot \Delta_m^{-1} \cdot q_m \tag{7}$$

Let Δ_{jm}^{-1} be the j-th 1 by J row of Δ_m^{-1}. We get the following tranformed first-order conditions for each car j sold in market m:

$$\frac{1}{1+d_m} \cdot p_{jm} = mc_{jm} + \frac{1}{1+d_m} \cdot \Delta_{jm}^{-1} \cdot q_m \tag{8}$$

In words, the equilibrium price of each car j in market m is additively separable in its own marginal cost, and a markup over marginal cost. These components are the two possible sources for price differences across car types and across markets. Both components are discussed in turn.

The functional form of the *marginal cost* component in equation (8) generalizes (1) and becomes:

$$mc_{jm} = e^{w_{jm}\gamma + \overline{\omega}_{jm}} \tag{1'}$$

where w_{jm} is a vector of physical characteristics of car j in market m. The error term $\overline{\omega}_{jm}$, used before in the hedonic model, now has the economic interpretation of capturing unobserved (to the econometrician) car characteristics that influence the marginal cost of producing car j in market m. It contains a systematic term specific to the market m in which the car is sold and an unsystematic term specific to both the market m and car j:

$$\overline{\omega}_{jm} = \omega_m + \omega_{jm}$$

The systematic term ω_m may be the consequence of differences in cost-increasing national regulations, such as the required used of catalytic converters in Germany. Substitute the expression for marginal cost in the pricing equation to get:

$$\ln\left(p_{jm} - \Delta_{jm}^{-1} \cdot q_m\right) = \ln(1+d_m) + w_{jm}\gamma + \omega_m + \omega_{jm} \tag{9}$$

Using (4), and assuming that $\ln(1+\tau_m)=\tau_m$ holds approximately, we get:

$$\ln\left(p_{jm} - \Delta_{jm}^{-1} \cdot q_m\right) = \ln(1+t_m) + w_{jm}\gamma + \tau_m + \omega_m + \omega_{jm} \tag{10}$$

The systematic terms ω_m and τ_m are fixed effects that may be estimated using dummy variables. Notice, however, that τ_m is not separately identified from ω_m.[6] The estimated fixed effects, therefore, cannot be narrowly interpreted as systematic differences in the marginal costs of producing in the various markets. Rather, they must be interpreted more broadly to include systematic differences in percentage deviations of the list price from the actual price received by the firms. Hence, the estimated fixed effects reflect a wide variety of factors causing systematic differences in the "cost of operating" in the various markets, such as systematic differences in the marginal cost of producing, differences in the market-average dealer markups, errors in measured tax rates or unmeasured temporary exchange rate fluctuations.

The markup component in equation (8) is crucial to examine the possible presence of international price discrimination in the European car market. The *relative* markup of a car j in market m is

$$\frac{p_{jm}/(1+d_m) - mc_{jm}}{p_{jm}/(1+d_m)} = \frac{1}{p_{jm}} \cdot \Delta_{jm}^{-1} \cdot q_m \tag{11}$$

Note that the *relative* markup is independent of d_m. This is convenient since d_m depends on τ_m, which is, as shown above, not separately identified from ω_m. As (11) shows, the relative markup depends on the demand side of the market only. In the special case in which car j is produced by a one-product firm, the relative markup $\frac{1}{p_{jm}} \cdot \Delta_{jm}^{-1} \cdot q_m$ contains no cross-demand derivatives and can be reduced to the well-known form: the inverse of its own-price elasticity. In the general case in which car j is produced by a multiproduct firm, the relative markup does contain cross-demand derivatives.

In this case the relative markup may be said to equal the inverse of some "adjusted" price elasticity.

An extremely simple way to introduce the demand side in order to estimate markups would be by positing the following pattern of price elasticities: let the own- and cross-price elasticities be constant and equal for all car types operating in the same market. In this case the relative markups are also equal for all car types operating in the same market. The pricing equation then can be reduced to the hedonic pricing equation where the fixed effects now capture systematic markup differences across the various markets in addition to systematic cost differences. Of course, this specification is *ad hoc*, and even more importantly, it cannot identify cost differences from markup differences without imposing further restrictions.[7] Fortunately, recent theoretical models have introduced the demand side in oligopoly theory in an economically meaningful way by explicitly modelling the nature of *product differentiation* that characterizes the industry.[8] Bresnahan (1981, 1987) and Berry (1991) have shown how these models can be applied in an econometrically tractable way. In the next subsection I develop an appropriate model of product differentiation for the European car market. Essentially, as will be seen, that model obtains identification between cost differences and markup differences from data on each car type's sales.

3.2. Aggregate demand

There are L_m potential consumers located in each market m; the sum of L_m across the various national markets, L, constitutes the total market. Each consumer faces the following discrete-choice problem: either buy one car j in market m at price p_{jm}, or buy none. If no car is chosen, an "outside good" is purchased in one of the markets at a price p_{0m}. The outside good is a measure of all other goods to which the consumer budget may be allocated. Its existence guarantees that the total demand for cars is not perfectly inelastic: a general increase in car prices reduces the total number of cars purchased because of substitution to the outside good.

Let indirect utility of consumer i from buying car j in market m be:

$$u^i_{jm} = \delta_{jm} + \nu^i_{jm} \tag{12}$$

This specification shows that indirect utility consists of two parts: a mean-utility part equal for all consumers, and a random deviation from that mean, ν^i_{jm}, specific to each individual consumer. Specify the mean utility part δ_{jm} as

$$\delta_{jm} = x_{jm}\beta - \alpha \frac{(p_{jm})^{\mu} - 1}{\mu} + \xi_{jm} \tag{13}$$

where x_{jm} and ξ_{jm} denote observed and unobserved (to the econometrician) physical characteristics of car j in market m. The unobserved term ξ_{jm} contains a systematic term specific to market m, ξ_m, and an unsystematic term specific to both market m and carj, ξ_{jm}. ξ_{jm} is of a similar nature as, and may indeed be correlated to, the term of unobserved characteristics affecting marginal cost, ω_{jm}. Notice the flexible way in which price enters the mean utility part.[9] Traditionally, $\mu=1$, generating an indirect utility that is linear in price. The specification in (13) allows for $\mu<1$. For example, if μ approaches 0, the indirect utility becomes linear in the logarithm of price. The flexible form of the price variable will generate flexible price elasticities and relative markups.[10]

The distribution of the individual-specific part of utility, ν^i_{jm}, crucially determines the functional form of aggregate demand for each car j in market m, and correspondingly the substitution patterns and relative markups. Generally speaking, the distribution of ν^i_{jm} need not be i.i.d. It may be *conditional* on the observed and unobserved characteristics in x_{jm} and ξ_{jm} or on some other physical characteristics. The conditional distribution of ν^i_{jm} allows a consumer's utility for a specific car j in market m to be correlated with other cars that have similar characteristics. For example, a consumer from a large household may have correlated preferences over all large cars. At the aggregate level, the conditional distribution of ν^i_{jm} generates substitution patterns that allow for a localized notion of competition: cars with similar characteristics attract consumers with similar tastes for these characteristics, making them "close neighbours" in the product space.

The nested logit model of product differentiation starts from an economically appealing and still econometrically tractable distribution of ν^i_{jm}. Berry outlines a simple version in an oligopoly context. I develop here an extended version, to conform to the peculiarities of the European car market. Assume the set of car types in each market m may be partitioned into G_m+1 groups, $g=0,1,\ldots G_m$. Group 0 is reserved for the outside good. Cars belonging to the same group have in common one physical characteristic: class. Assume in addition that each group can be further partitioned according to country of origin into H_{gm} subgroups, $h=1,\ldots,H_{gm}$. Specify the individual-specific part of utility for car j in market m, ν^i_{jm}, as:

$$\nu^i_{jm} = \varepsilon^i_m + \varepsilon^i_{gm} + (1-\sigma_2)\varepsilon^i_{hgm} + (1-\sigma_1)\varepsilon^i_{jm} \tag{14}$$

Let the distribution of ϵ^i_m across all individuals in the European car market take an extremely simple form: $\epsilon^i_m=0$ if i is one of the L_m consumers located in market m, and $\epsilon^i_m=-\infty$ if i is not one of the L_m consumers located in market m. This assumption says there are prohibitive arbitrage costs of travelling to another market.

The distributions of ϵ^i_{gm}, ϵ^i_{hgm} and ϵ^i_{jm} are standard to the nested logit model: they have the unique distribution such that ϵ^i_{gm}, $(1-\sigma_2)\epsilon^i_{hgm} + (1-\sigma_1)\epsilon^i_{jm})$ and $\epsilon^i_{gm} + (1-\sigma_2)\epsilon^i_{hgm} + (1-\sigma_1)\epsilon^i_{jm})$ have the extreme value distribution.[11] As shown by McFadden, we must have $0\leq\sigma_2\leq\sigma_1\leq1$ for the model to be consistent with random utility maximization. Note that the distribution of $\epsilon^i_{gm} + (1-\sigma_2)\epsilon^i_{hgm} + (1-\sigma_1)\epsilon^i_{jm})$ is i.i.d. only if $\sigma_1=\sigma_2=0$. In this case the well-known simple logit model results. In the general case, the distribution is conditional on two physical characteristics of cars: class and country-of-origin within a given class. The magnitude of the parameters σ_1 and σ_2 determine the importance of these characteristics in the distribution of the individual-specific taste variable. As σ_1 increases, preferences become correlated across all car types belonging to the same subgroup. When σ_1 approaches 1, preferences are perfectly correlated across cars types belonging to the same subgroup, so that cars from the same subgroup become perfect substitutes. Similarly, as σ_2 increases, preferences also become correlated across all subgroups belonging to the same group. When σ_2 approaches σ_1, preferences are perfectly correlated across the subgroups belonging to the same group, so that subgroups from the same group become perfect substitutes. Put differently, when σ_2 approaches σ_1, preferences are correlated only across car types belonging to the same group; there is no separate correlation across car types belonging to the same subgroup, and across subgroups belonging to the same group. All these alternative possibilities are testable hypotheses to be taken to the data.

To derive *aggregate* demand for each car j in market m, consider the well-known formulas for the conditional choice probabilities in the nested logit model:[12]

$$s_{j/hgm} = \frac{e^{\delta_{jm}/(1-\sigma_1)}}{\left(D_{hgm}\right)} \tag{15a}$$

$$s_{h/gm} = \frac{\left(D_{hgm}\right)^{(1-\sigma_1)/(1-\sigma_2)}}{D_{gm}} \tag{15b}$$

$$s_{g/m} = \frac{\left(D_{gm}\right)^{1-\sigma_2}}{\sum_{g=0}^{G_m} \left(D_{gm}\right)^{(1-\sigma_2)}} \tag{15c}$$

where D_{hgm} and D_{gm} are defined as:

$$D_{hgm} \equiv \sum_{l=1}^{L_{hgm}} e^{\delta_{lm}/(1-\sigma_1)} \tag{16}$$

$$D_{gm} \equiv \sum_{h=1}^{H_{gm}} D_{hgm}^{(1-\sigma_1)/(1-\sigma_2)} \tag{17}$$

The conditional choice probability $s_{j/hgm}$ is the probability that a consumer buys car j given that he buys a car from the subgroup hgm. Similarly, $s_{h/gm}$ is the probability that a consumer buys from the subgroup hgm given that he buys from the group gm. Finally, $s_{g/m}$ is the probability that a consumer buys from the group gm given that he buys from market m. All these conditional choice probabilities approximate (observable) aggregate market shares: $s_{j/hgm}$ approximates the aggregate share of car j in its subgroup hgm; $s_{h/gm}$ approximates the aggregate share of a subgroup hgm in its group gm; $s_{g/m}$ approximates the share of group g in the market m.

The choice probability s_m is the probability that a consumer buys a car from market m. Under the distributional assumption for ϵ^i_m, guaranteeing no arbitrage, we have

$$s_m = \frac{L_m}{L} \tag{15d}$$

Again, the choice probability s_m equals the share of market m in the total market.

Combining all these probabilities, or approximately market shares, gives the aggregate demand equation for car j in market m:

$$q_{jm} = s_{j/hgm} \cdot s_{h/gm} \cdot s_{g/m} \cdot s_m \cdot L$$

$$= \frac{e^{\delta_{jm}/(1-\sigma_1)}}{(D_{hgm})} \cdot \frac{(D_{hgm})^{(1-\sigma_1)/(1-\sigma_2)}}{(D_{gm})} \cdot \frac{(D_{gm})^{1-\sigma_2}}{\sum_{g=0}^{G_m} (D_{gm})^{(1-\sigma_2)}} \cdot L_m \tag{18}$$

Notice that q_{jm} is a function of the car type's own price and of the price of its competitors sold in the *same* market. The price of car types sold in other markets does not enter q_{jm}. This follows of course from the distributional assumption for ϵ^i_m, guaranteeing no arbitrage. The price elasticities implied by the demand equation can be easily calculated by taking the appropriate demand derivatives:

$$e_{jjm} \equiv -\frac{\partial q_{jm}}{\partial p_{jm}} \cdot \frac{p_{jm}}{q_{jm}} = \alpha p_{jm}^{\mu} \cdot \left(\frac{1}{1-\sigma_1} - \left(\frac{1}{1-\sigma_1} - \frac{1}{1-\sigma_2} \right) s_{j/hgm} - \frac{\sigma_2}{1-\sigma_2} s_{j/gm} - s_{j/m} \right) \tag{19a}$$

$$e_{jkm} \equiv \frac{\partial q_{km}}{\partial p_{jm}} \cdot \frac{p_{jm}}{q_{km}} = \alpha\, p_{jm}^{\mu} \cdot \left(\left(\frac{1}{1-\sigma_1} - \frac{1}{1-\sigma_2} \right) s_{j/hgm} + \frac{\sigma_2}{1-\sigma_2} s_{j/gm} + s_{j/m} \right) \tag{19b}$$

$$e_{jk'm} \equiv \frac{\partial q_{k'm}}{\partial p_{jm}} \cdot \frac{p_{jm}}{q_{k'm}} = \alpha\, p_{jm}^{\mu} \cdot \left(\frac{\sigma_2}{1-\sigma_2} s_{j/gm} + s_{j/m} \right) \tag{19c}$$

$$e_{jk''m} \equiv \frac{\partial q_{k''m}}{\partial p_{jm}} \cdot \frac{p_{jm}}{q_{k''m}} = \alpha\, p_{jm}^{\mu} \cdot s_{j/m} \tag{19d}$$

where k, k' and k'' index cars that respectively belong to the same subgroup, to the same group, and to a different group. These elasticities show that the intuition for individual preferences carries over to aggregate demand. This is most clearly illustrated by the pattern of *cross-price* elasticities:

$e_{jkm} \geq e_{jk'm} \geq e_{jk''m}$ with equality only if $\sigma_1 = \sigma_2 = 0$. This reflects the localized nature of competition: cars belonging to the same subgroup or group attract consumers with similar tastes making them "closer neighbours" in the product space.

It is useful to consider here how the price elasticities enter the pricing equation derived in the previous subsection. Recall that the pricing equation consists of two parts: a cost and a markup component. Take the simple case of one-product firms so that the relative markups of the car types equal the inverse of their own-price elasticity.[13] Data on sales, which enter the formula for the own-price elasticity through the observables $s_{j/m}$, $s_{j/gm}$ and $s_{j/hgm}$, are consequently able to identify differences in relative markups across car types and across markets from differences in costs. The greater is the variation in the sales across cars and across markets, the more variation there is in the price elasticities and relative markups. Note how the parameters σ_1 and σ_2 interact with the observables $s_{j/m}$, $s_{j/gm}$ and $s_{j/hgm}$. A high $s_{j/m}$ implies a low own-price elasticity and a high relative markup. In addition, for $\sigma_2 > 0$, a high $s_{j/gm}$ implies a low own-price elasticity and a high relative markup. Finally, for $\sigma_1 > \sigma_2$, a high $s_{j/hgm}$ implies a low own-price elasticity and a high relative markup. The role of the parameter μ, and its interaction with the observed price, is also clear. If $0 < \mu \leq 1$, a high observed price implies a high elasticity and a low relative markup. If $\mu = 0$, the observed price is independent of the elasticity and relative markup. If $\mu < 0$, a high observed price implies a low elasticity and a high relative markup.

3.3. Extension 1: the model with import quota

The above discussion has focused on a simple model of product differentiation to explain the pattern of elasticities and markups across cars and across markets. In that model international price discrimination, as measured by differences in relative markups across countries, solely follows from differences in elasticities. In this and the next section I extend the model to allow for other factors that may be responsible for the presence of price discrimination in the European car market.

The European car market is characterized by various trade restrictions. Although the European Commission has devoted considerable effort towards liberalizing trade within the Community, various trade barriers remain. More importantly, serious import quota on Japanese cars exist in several European countries. Table I illustrates this fact. Especially France and Italy protect their market from Japanese imports. It is clear that these quota should affect the competitive conditions in the industry. In particular, the supply side of the market will change. One may expect that the Japanese car manufacturers will charge higher markups in countries with binding quota constraints. To model this source of international price discrimination, follow Goldberg (1993) and assume that the Japanese firms maximize their profits with respect to prices, subject to the constraint that they cannot increase the demand for their cars above the quota level Q_{fm}, i.e.

$$\max \Pi_{fm} = \sum_{k=1}^{K_{fm}} \left[\frac{p_{km}}{1+d_m} - mc_{km} \right] \cdot q_{km}(p_{1m}, p_{2m}, \dots, p_{Jm}) + \lambda_{fm}\left(Q_{fm} - \sum_{k=1}^{K_{fm}} q_{km}\right) \tag{20}$$

Assuming that the Japanese government allocates quotas such that $\lambda_{fm} = \lambda_m$ for all Japanese firms f in market m, the first-order condition of the Japanese firms becomes:

$$\sum_{k=1}^{K_{fm}} \left[\frac{p_{km}}{1+d_m} - mc_{km} - \lambda_m \right] \cdot \frac{\partial q_{km}(p_{1m}, p_{2m}, \dots, p_{Jm})}{\partial p_{jm}} + q_{jm}(p_{jm}, p_{2m}, \dots, p_{Jm}) \cdot \frac{1}{1+d_m} = 0 \tag{21}$$

This equation can be straightforwardly applied to the nested logit model of product differentiation discussed above. λ_m can be interpreted as the shadow cost for Japanese firms of operating in market m, and may be estimated using dummy variables. An estimated coefficient significantly greater than zero in market m indicates that the import quota are binding in market m and hence alter the relative markups of Japanese firms.[14]

3.4. Extension 2: the model with collusive behavior

The models developed above assume that firms *unilaterally* set the price of their cars marketed. If firms do not unilaterally set prices, but if they *coordinate* their actions and collude, positive markups and international price discrimination may occur even in the absence of product differentiation and quota constraints. To empirically investigate the existence of collusion, and of various degrees of collusion in different markets, a "conjectural-variations" model is a useful first step.

Consider the following conjectural variations. Assume firm f marketing car j in market m expects that an increase in the price of its car j in market m by 1 unit is "matched" with an increase in the price of the rival cars in market m by ϕ_m units, where $-1<\phi_m<1$. Furthermore, assume the price match is expected only from rival cars belonging to the same group. In sum, assume $dp_{lm}/dp_{jm}=\phi_m$, for all cars belonging to the same group as car j, and $dp_l/dp_j=0$ otherwise. These conjectural variations generate the following pricing equation:

$$\left[\frac{p_{jm}}{1+d_m}-mc_{jm}\right]\cdot\left[\frac{\partial q_{jm}}{\partial p_{jm}}+\sum_{k'}\frac{\partial q_{jm}}{\partial p_{k'm}}\cdot\phi_m\right]+\sum_{k=1,k\neq j}^{K_{fm}}\left[\frac{p_{km}}{1+d_m}-mc_{km}\right]\cdot\frac{\partial q_{km}}{\partial p_{jm}}+q_{jm}\cdot\frac{1}{1+d_m}=0 \tag{22}$$

where k' indexes all cars belonging to the same group. If $\phi_m=0$, the pricing equation reduces to the pricing equation without collusion. Essentially, conjectural variations allow the econometrician to *approximate* - rather than to model explicitly - collusive considerations in the firm's pricing problem. From an econometric perspective, conjectural variations are no different from collusive approximations.[15] Ideally, however, a structural model should be formulated to incorporate the possibility of collusive behavior, such as a repeated game model. This would allow us to obtain a "correct" functional form. In addition, it would allow us to formally incorporate new variables that influence collusion, e.g. variables that influence the discount factor across markets in a repeated game model.

4. Econometric considerations and data

4.1. Econometric considerations

Investigating the presence of international price discrimination requires estimation of the equilibrium pricing equation after the appropriate substitutions of the demand derivatives. To obtain cross-equation restrictions I also estimate the demand equation. In this subsection, I consider the econometric issues that need to be addressed to obtain a consistent, precise and computationally tractable estimator. This discussion is largely based on recent work by Berry (1994) and Berry, Levinsohn and Pakes (1993).

Throughout the paper I assume that the vectors of observed physical characteristics w_{jm} and x_{jm} are exogenous and consequently orthogonal to the error terms ω_{jm} and ξ_{jm}. This exogeneity assumption forms the main identification assumption for estimation of the pricing and the demand equation. This assumption is at least reasonable in the short run, because firms cannot quickly adjust the characteristics of their cars marketed. In the long run, when firms are able to choose the characteristics of their cars, the assumption may be more problematic.

Prices and market shares are endogenous and correlated with the error terms ω_{jm} and ξ_{jm}, even in the short run. This is because they are simultaneously determined in a Bertrand-Nash equilibrium. Therefore, ordinary least squares estimators are inconsistent, suggesting the need for an instrumental variable estimator. Unfortunately, a computational issue arises. The error terms ω_{jm} and especially ξ_{jm}, which need to be interacted with the chosen instruments, appear nonlinearly in the demand and pricing equation. Berry (1994) proposes and justifies the following approach in the context of discrete choice models of oligopoly: (1) transform the demand and pricing equation such that the error terms enter linearly, and (2) choose appropriate instrumental variables that can be interacted with the solution of the error term. Both steps are discussed in turn.

(1) Transformation of the demand and pricing equation: Consider first pricing equation (5). The error term ω_{jm}, as well as the ω_{km}, enter nonlinearly through the marginal cost function (1)'. The pricing equation was transformed into (10) after taking the appropriate logarithms and inverting a matrix of demand derivatives. The Appendix shows how the matrix of demand derivatives is actually inverted for the nested logit model. The required transformation of demand equation (11) is also developed in the Appendix.[16] The resulting transformations are presented here:

Demand

$$\ln(s_{j/m}) = \ln(s_{0/m}) + (\sigma_1 - \sigma_2)\ln(s_{j/hgm}) + \sigma_2 \ln(s_{j/gm}) + x_{jm}\beta - \alpha \frac{(p_{jm})^{\mu} - 1}{\mu} + \xi_m + \xi_{jm} \tag{23a}$$

Pricing

$$\ln\left[\frac{p_{jm}}{1+d_m} - \frac{1}{\alpha}\frac{p_{jm}^{1-\mu}}{1+d_m}\frac{1}{r_{jm}}\frac{1-\sum \frac{s_{k/m}}{r_{jm}}\left[1-\left[\frac{p_{km}}{p_{jm}}\right]^{1-\mu}\right]}{1-\sum \frac{s_{k/m}}{r_{jm}}} - \lambda_m\right] = w_{jm}\gamma + \omega_m + \omega_{jm} \tag{23b}$$

where

$$r_{jm} \equiv (1-\phi_m)\left[\frac{1}{1-\sigma_1} - \left[\frac{1}{1-\sigma_1} - \frac{1}{1-\sigma_2}\right] s_{j/hgm} - \frac{\sigma_2}{1-\sigma_2} s_{j/gm}\right] + \phi_m(1 - s_{g/m} + s_{j/m}) \tag{24}$$

The error terms ω_{jm} and ξ_{jm} enter linearly in these transformed equations so that a computationally tractable estimator is possible. Some of the parameters, however, enter nonlinearly so that nonlinear minimization techniques will be required. The reader may verify how the pricing equation would simplify if σ_1, σ_2 or μ are set equal to zero, or if a single-product firm's pricing equation is considered.[17]

(2) The choice of appropriate instruments: In homogeneous goods models of supply and demand

instruments are readily available: there are generally enough exogenous variables that affect marginal cost and not demand, and exogenous variables that affect demand but not marginal cost. In the present model of product differentiation, most exogenous variables, the observed physical characteristics, affect both marginal cost and demand. Indeed, it is even possible that $w_{jm}=x_{jm}$, in which case no traditional instruments can be used. Fortunately, other instruments are available. Because the pricing equation holds for all cars simultaneously, constituting a Nash equilibrium, the physical characteristics of each car's competitors are correlated with its own price and demand. Consequently, (functions of) these variables may be used as instruments. Pakes (1993) and Berry, Levinsohn and Pakes (1993) discuss the general question of how to obtain efficient instruments when any function of competitors' characteristics are potential candidates. They show that the following variables approximate efficient instruments: the elements of the vectors of exogenous variables x_{jm} and w_{jm}, the average of the elements of the exogeneous variables across other cars belonging to the same firm, and the average of the elements of the exogenous variables across other cars not belonging to the same firm. I choose to use these instruments in the used estimator.

A standard remark on the used estimator applies. The error terms ξ_{jm} and ω_{jm} are likely to be correlated: unobserved characteristics that affect the marginal cost of car j, may also affect the demand for car j. Consequently, an initial (consistent) estimate of the covariance matrix of ξ_{jm} and ω_{jm} is necessary to get a more efficient estimator. (Nonlinear) three-stage least squares is an appropriate instrumental variable method to cope with this problem.

4.2. The data

The vectors of physical characteristics w_{jm} and x_{jm}, affecting the marginal cost and the mean utility for a car, contain the same elements and may be summarized in two categories. The first category consists of the technical characteristics horsepower, weight, width and height. Horsepower, weight and height (measuring aerodynamics) jointly determine the performance variables *speed* and *acceleration*. Both width and weight capture *safety*. Width and height capture *size* or *comfort*. Note that the technical characteristics enter x_{jm} logarithmically, so that their coefficients may be interpreted as elasticities. The second category of physical characteristics in w_{jm} and x_{jm} consists of country-of-origin dummy variables. The coefficients of French, German, Italian, UK, US and Japanese cars are to be interpreted relative to the "other" cars, mainly Eastern European. An interaction dummy reflects a systematic disadvantage to foreign firms. The country-of-origin variables in the vector w_{jm} capture unobserved differences in the marginal cost of producing cars of a given origin, due to differences in productivity across countries, etc... The country-of-origin variables in the vector x_{jm} capture unobserved differences in the mean utility for cars of a given origin. In addition, the country-of-origin variables in both w_{jm} and x_{jm} capture differences in cost-increasing and demand-reducing trade restrictions that are systematically imposed against cars from a particular country. The coefficients of the dummy variables cannot identify these alternative possibilities; more data on cost and taste differences and on differences in trade restrictions against the various countries are required to achieve identification. Nevertheless, inclusion of these dummy variables helps to avoid bias of the estimators of the other coefficients.

In addition to the physical characteristics that affect the marginal cost and the *mean* utility for a car, two physical characteristics affect *individual-specific* deviations from the mean utility: class and country-of-origin within a given class. European cars are partitioned into six classes, based on common marketing classifications: mini and small, medium, large, executive, luxury and sports.[18] Each class is split into two subgroups according to its country of origin: home cars and foreign cars.

The fixed effects in the demand equation, the ξ_m, and in the pricing equation, the ω_m and the τ_m, capture unobserved systematic differences influencing demand and pricing across the various national markets. Recall that the τ_m are not identified from the ω_m. Hence, the estimated fixed effects in the pricing equation ought to be interpreted in a broad sense: in addition to capturing systematic differences in the marginal cost of producing in the various markets due to different national regulations, they capture systematic differences in dealer markups, and possible errors in measured tax rates or exchange rates.

All prices are list prices and are converted into ECU's using period average market rates. Value added taxes are included. Sales are the annual number of registrations. World production data are collected to consider the possibility of returns to scale. Almost all available car models are included in the sample with the exception of those models with extremely low market shares. This gives a sample of 512 observations in 1990, spread over five European countries: Belgium, France, Germany, Italy and the United Kingdom. All data come from publicly available sources, including: *l'Argus de l'Automobile et des Locomotions, Auto Moto Revue, Journal de l'Automobile, Katalog der Automobil Revue, Nieuwe tot het Verkeer Toegelaten Voertuigen, Notziario Statistica, Tatsachen und Zahlen aus der Kraftsverkehrswirtschaft, World Motor Vehicle Data*. Additional data on the Netherlands and Spain would be desirable, as their market size falls within the included range.

So far, the market shares of the various cars, $s_{j/m}$, and the market share of the outside good, $s_{0/m}$, have been taken as observables. In fact, $s_{j/m}$ and $s_{0/m}$ depend on the number of potential consumers L_m in each market m.[19] Provided that there are enough markets included in the sample, L_m may in principle be estimated using market-level data that determine L_m, such as population, income or the total demand for cars - a durable good - in previous periods.[20] For purposes of the present paper, in which only five markets are considered, I choose to keep L_m as a known variable. Berry, Levinsohn and Pakes (1993) set L_m equal the total number of households in the economy, assuming each household is a potential buyer of a new car in every year. Considering the durable nature of cars, I assume that only 25 percent of the households is a potential buyer a new car; the other households are interested only in buying a car on the second-hand market (in which they are likely to repurchase their own car). Although this number is somewhat arbitrary, I believe it is closer to reality than is the assumption of Berry, Levinsohn and Pakes. In any case, the empirical results were robust to alternative specifications of L_m.

5. Empirical Results

I find that the observed price differences in the European car market can be at least partly attributed to the practice of international price discrimination. Firms actively exploit cross-country differences in price elasticities, and Japanese firms also take into account differences in quota regimes. It cannot be ruled out that firms are also colluding to a different degree in the various countries.

To support my findings I split the discussion into three parts. The first part confronts the estimates of the simple hedonic pricing equation with those of the logit and the nested logit model with quota constraints. I establish the importance of the nested logit model with quota constraints and suggest the possible presence of international price discrimination. The second part discusses the estimates of the nested logit model with quota constraints in detail, after allowing for returns to scale. The calculated relative markups for selected cars demonstrate that there exists indeed international price discrimination. The first two parts set the parameter μ and the conjectural variations equal to zero. The third part considers two extensions: one in which the parameter μ is estimated freely and one with positive conjectural variations. As a statistic that summarizes the findings on international price discrimination, Lerner indices for the various nested logit specifications are calculated.

5.1. The Hedonic versus the Logit and the Nested Logit Model

Table IV presents instrumental variable estimates of the logit and the nested logit model with quota constraints. The parameter μ is set equal to zero. Recall that the hedonic pricing equation may be interpreted as a competitive pricing equation with zero markups. Alternatively, it may be interpreted as an oligopolistic pricing equation with positive relative markups that are constant and identical for all car types in the same market. Yet, even in this interpretation, the hedonic pricing equation cannot identify systematic cost differences across countries from differences in markups. This is in contrast to the logit and nested logit specification in which identification is obtained through data on sales. The simple logit model, starting from an i.i.d. assumption on the distribution of individual preferences, predicts global competition. The nested logit model allows for localized competition within subgroups and groups. To confront the three models with each other I first calculate some test statistics. Next I consider the stability of the parameter estimates across the three models.

Testing the logit and the nested logit model amounts to testing the (joint) significance of α, σ_1 and σ_2. A simple t-test statistic shows that the hedonic pricing equation may be rejected in favour of the logit model. The t-test statistic for α is 7.954, much above the critical level at 99 percent significance.[21] To test the logit model against the nested logit model, a likelihood-ratio or Wald test statistic can be developed. The likelihood-ratio test statistic uses both the estimates of the unrestricted and the restricted model; the Wald test statistic uses only the estimates of the unrestricted model. Both test statistics are applicable to models estimated with nonlinear three-stage least-squares. They are distributed asymptotically as a chi-square random variable with degrees of freedom equal to the number of imposed constraints. Both the likelihood-ratio and the Wald test statistic show that the logit model can be rejected in favour of the nested logit model. The likelihood-ratio test statistic for joint significance of σ_1 and σ_2 is 90.769; the Wald test statisitic is 94.662. Both numbers are much above the critical level at 99 percent significance with 2 degrees of freedom. Both numbers are very high despite the very imprecise estimate of σ_2. (The t-statistic of σ_2 is only 0.135.)[22] The joint significance of σ_1 and σ_2 suggests that competition is localized. The high significance of σ_1 and the insignificance of σ_2 suggests that competition is especially localized within subgroups.

Consider now the significance of the quota constraints as captured by the dummy variables for λ_m . Because there are no quota constraints in Belgium, this coefficient was set equal to zero. As clear from Table I all other countries impose either unvoluntary or volutary quota constraints against Japanese car manufacturers. Testing whether these quota constraints were actually binding amounts to testing the significance of the coefficient of each dummy variable. This shows at a 95 percent significance level that the quota constraints were indeed binding in France and Italy, the countries with the most severe quota constraints. In Germany and the United Kingdom the quota restrictions were not actually binding.[23]

A topic of interest complementary to formal hypothesis testing is the stability of the various parameters across the various specifications. What is the effect of including α, σ_1, σ_2, and the dummy variables for λ_m on the estimates of the other coefficients? Consider first the *demand* coefficients. Many estimated coefficients in the logit model are affected by the inclusion of the new parameters, σ_1 and σ_2, in the nested logit model. The most interesting change is the coefficient of the interaction dummy capturing the foreign firm effect. It is significantly lower (in absolute value) in the nested logit model. This shows that the significant coefficient σ_1, capturing the *individual-specific* foreign firm effect on utility, partially takes over the *mean utility* effect of the interaction dummy in the simple logit specification. Some other coefficients in the demand equation change after σ_1 is included, such as the technical characteristics width and height, and some of the country-of-origin dummies. These effects may again be taken over by σ_1, for some not so obvious reason.

Consider now the *cost* coefficients. Most estimated coefficients in the hedonic pricing equation are unaffected by the inclusion of the new parameters in the logit and in the nested logit model. There is one important exception. The estimated fixed effects in the logit and especially in the nested logit model are all lower relative to Belgium than in the hedonic pricing equation. Apparently, in the hedonic pricing equation these fixed effects were overestimated: they took over the effects of an omitted (function of) sales variable, interacted with the parameters α, σ_1 and σ_2, and of the omitted quota constraints. To understand this, recall that in the competitive interpretation of the hedonic pricing equation all systematic price differences across countries are due to cost differences as captured by the fixed effects. In the oligopolistic pricing equations, price differences across countries may also be due to markup differences. The lower estimates of the fixed effects in the oligopolistic pricing equations, together with the significant estimates of α, σ_1 and σ_2, and of some of the quota constraints, then suggest that differences in markups, or international price discrimination, is at least a partial explanation for the observed price differences in the European car market. To verify this possibility, I explicitly calculate the markups implied by the estimates in the next subsections.

5.2. The nested logit model

The above discussion showed the empirical relevance of the nested logit model with quota constraints compared to more simple models. To add realism I now introduce the possibility of returns to scale in the cost function. More precisely, let world production of each car type enter the the vector w_{jm} logarithmically, with coefficient γ^r. It is straightforward to show that elasticity of total variable cost with respect to production equals $1+\gamma^r$.[24] I deliberately did not include the production variable in the cost function in the previous subsection. This allowed for a "clean" comparison of the hedonic pricing equation with the logit and the nested logit models: world production is indeed highly correlated to the sales variables that play such an important role in the logit and nested logit models.

Table V gives the empirical results of the "base" specification of the nested logit model with returns to scale. First consider the *demand* coefficients influencing the mean utility. Recall that the coefficients on the technical characteristics may be immediately interpreted as elasticities. Both the elasticity of horsepower and width have the expected sign and are estimated precisely. Demand is especially elastic with respect to width. Weight and height enter demand insignificantly. This may be explained by the fact that weight and height have an ambiguous impact on underlying performance variables: weight increases safety, but reduces speed/acceleration; height increases size/comfort, but decreases speed/acceleration. The significant variables horsepower and width do not have such an ambiguous impact.

Country of origin seems an important differentiating physical characteristic. Interpreting the country-of-origin variables as capturing direct differences in taste, it follows that consumers have a high preference for German cars, a lower preference for French and European built US cars, and the lowest preference for UK, Italian, Japanese and other (mainly Eastern European) cars. Of course, as argued in the discussion of the data, the country-of-origin variables may also capture systematic demand-reducing trade restrictions against certain countries, in addition to direct taste differences. For example, car manufacturers from some countries may have more difficulties in establishing an appropriate dealer network. Additional data would be required to identify taste differences from differences in trade restrictions. A similar remark applies to the (significant) coefficient capturing the foreign firm disadvantage effect.

Now consider the demand coefficients that enter the price elasticities and hence also the pricing equation: α, σ_1 and σ_2. They all satisfy the restrictions of the nested logit model, i.e. $\alpha > 0$, $0 < \sigma_2 < \sigma_1 < 1$, although σ_2 is estimated rather imprecisely. The estimates of these parameters are responsible for a plausible set of price elasticities, in contrast to elasticities implied by the simple logit models. This is illustrated by Table VI, providing price elasticities for selected cars in Germany and Italy. These are based on the formulas given in the text. The own-price elasticities vary between 4 and 7, consistent with estimates in Berry, Levinsohn and Pakes, although they obtain a somewhat larger variation across cars.[25] Domestic cars usually have the smallest elasticity, which follows from the fact that they operate in an uncrowded subgroup with little competition. The cross-price elasticities are also intuitive. A percentage decrease in the price of a car reduces the demand of cars belonging to the same subgroup with a higher percent than the demand of cars that belong to a different subgroup or group. Note also that some cars have a higher impact on the demand of their competitors within the same group than other cars. For example, in both Italy and Germany, a VW Golf can steal more business from its competitors via price reductions than a Renault 19.

Now consider the estimated *cost* coefficients. The coefficient on production revails that there are significant returns to scale. Increasing production of a car by 10 percent increases total variable cost by only (10-1.4)=8.4 percent.[26] Consistent with previous hedonic studies, the technical characteristics entering the marginal cost equation all significantly contribute to marginal cost in the expected direction. The country-of-origin dummies all have positive coefficients relative to "other" (mainly Eastern European) countries. German cars have the highest estimated coefficient. Whether the country-of-origin differences are due to differences in productivity across the various countries or due to cost-increasing trade restrictions, cannot be identified from the available data. The foreign firm disadvantage effect on cost is significantly positive, indicating that foreign firms operate at a systematically higher cost, possibly due to some unobserved trade restriction.

The fixed effects show that the cost of operating is the highest in Germany and the UK. For Germany, this may be due to the obligated use of (expensive) catalytic converters. For the UK the high estimate is not so clear. A right-hand drive charge may play some role, but is clearly not a sufficient explanation.[27] A high market-average dealer markup in the UK may be a more plausible explanation.[28]

The estimates of the fixed effects were seriously altered by the inclusion of the world production variable. More interestingly, however, recall that the fixed effects were also seriously altered by the inclusion of the sales variables and quota constraints in the constant reurns to scale logit and nested logit models discussed in the previous subsection, suggesting the possibility of international price discrimination in the European car market. Do firms, in fact, exercise their market power unequally across the various countries and hence engage in international price discrimination? Consider Table VII, presenting relative markups for selected cars based on the estimates of the base specification of the nested logit model. The most striking fact about this table is the firms' ability to charge substantially higher markups on their cars sold domestically than on their cars sold abroad. In this sense, domestic firms can be said to price discriminate against the consumers in their home market. As extreme examples, compare the high markups of the Fiat Uno, Tipo and Croma in Italy to the much lower markups of Fiat elsewhere. Similarly, contrast the markups of the Renault 5 and 19 in France with the markups in other countries. The high significance of σ_1, in interaction with the sales variable $s_{j/hgm}$, is responsible for the strong domestic market power. Intuitively, there is a high degree of localized competition between cars belonging to the same subgroup. Domestic firms operate in less "crowded" subgroups than do foreign firms, resulting in lower own-price elasticities, which they exploit by charging higher markups.

Two other conclusions can be drawn from a reading of the relative markups in Table VII. First, the relative markups on Japanese cars are substantially higher than those on other cars in those countries where quota constraints were binding. This does not necessarily mean that the Japanese firms are better off due to the quota constraints. The increase in the Japanese firms' unit profits due to the quota may be offset by the reduction in the total number of cars sold. Second, the relative markups vary not only across countries, but also across classes. The high class cars tend to charge the highest markups. This can be verified by inspecting the markups of the Audi 80, and of the cars listed below the Audi 80. The only exception is the Fiat Croma, which can charge a high markup only in Italy. This general tendency follows from the fact that the high class cars compete in relatively uncrowded subgroups compared to the low and especially the mid-class cars.

5.3. Alternative specifications of the nested logit model and the Lerner-index as a summary statistic

In the base specification for the nested logit model, the parameter μ was set equal to zero. This generates elasticities and relative markups that do roughly not interact with the car type's own price.[29] The second column of Table V presents a specification in which μ was estimated. It turns out that μ is significantly negative: -0.287. This suggests, quite intuitively, that more expensive car types tend to have lower price elasticities and higher relative markups. The actual calculations, not shown here, revealed that this is indeed the case.

In the base specification for the nested logit model, the fixed effects in the pricing equation remained quite substantial. Thus, despite the presence of international price discrimination (as illustrated by the table on relative markups), quite substantial systematic cost differences remain a partial explanation for the observed price differences in the European car market. Even though the fixed effects have a broad interpretation -- including systematic differences in the marginal cost of producing across countries, differences in market-average dealer markups, and errors in measured tax rates or unmeasured temporary exchange rate fluctuations -- I find them quite substantial. Especially, the quite high estimated fixed effect for the United Kingdom is an important puzzle. The question arises whether these fixed effects do not take over some omitted variable. Until now, international price discrimination has been allowed to occur for two reasons: cross-country differences in price elasticities, and cross-country differences in quota regimes against some car manufacturers. The third column on Table V presents the estimates of a specification that allows for a third factor: cross-country differences in collusive behavior. Attempts were undertaken to estimate both the fixed effects and the conjectural variations, the ϕ_m, for the various markets, but the present sample could not identify the two effects. As an alternative, the fixed effects were set equal to zero and instead the conjectural variations were estimated for the various markets.[30] Except for the insignificant conjectural variation for France, all conjectural variations lie between zero and one, with the highest for the UK. The relative markups implied by the estimates of the model with conjectural variations (not shown here) are intuitive. First, differences in markups across subgroups are smoothed out, as may be expected from an equilibrium in which groups of car types collude.[31] Second, in Germany and especially the United Kingdom, with high conjectural variations, markups of *all* car types are relatively high, and not just those of the domestic and Japanese car types. This indicates international price discrimination may be partly the result of cross-country differences in collusive behavior, in addition to differences in elasticities and quota restrictions.

Much of the discussion on the empirical results with regard to international price discrimination may be summarized by one summary statistic: the Lerner-index. This index, commonly used in traditional industry case-studies, is defined as the sales-weighted average of relative markups in an industry. In traditional industry case-studies, the markups required to calculate the index are taken directly from accounting data. In the present study, the markups are *inferred* from observed pricing behavior. Estimated Lerner-indices for the various countries are presented in Table VIII. The first row gives the estimated Lerner-indices implied by the base specification for the nested logit model. Recall that this model allows for international price discrimination due to two factors: cross-country differences in price elasticities and differences of quota regimes. The Lerner indices differ substantially across countries. Belgium, with no domestic producer, has the lowest Lerner index. France, Germany and the United Kingdom have an up to 3 percent higher index. Italy has by far the largest Lerner-index: this is clearly the consequence of both elasticities and quota restrictions. In Italy unilateral domestic market power is important; the domestic firm Fiat has almost a monopoly as the single manufacturer in its subgroup. The Japanese firms are subject to a serious quota constraint of 1 percent. The estimated Lerner-indices for the nested logit model in which μ is estimated freely, presented on the second row, give a similar picture. Note that the levels are everywhere lower than in the base specification for the nested logit model. This is because the model predicts that relative markups are increasing in price, and because the lower priced car types, with the lower relative markups, have most of the sales. The estimated Lerner-indices for the nested logit model with conjectural variations, presented in the third row, give an entirely different picture. The estimated indices of Germany, Italy and the United Kingdom all increase. The increase of the Lerner-index for the United Kingdom is so high that it comes in the neighborhood of the Italian index. This was to be expected -- given the high degree of collusion that was estimated for the UK by the conjectural variations model.

6. Conclusions and Extensions

Observed price differences in the European car market have been puzzling to many economists and policymakers. This paper has used an oligopoly model with product differentiation to analyze to what extent the presence of international price discrimination can explain the puzzle. In addition to estimating marginal costs, I have also estimated the own- and cross-price elasticities of demand and the relative markups for all cars sold in 1990 in five European countries: Belgium, France, Germany, Italy and the United Kingdom.

My empirical results establish the presence of international price discrimination, as measured by cross-country differences in relative markups. Earlier studies have also analyzed the presence of international price discrimination, but cannot formally identify cross-country differences in relative markups from differences in the cost of operating in the various markets. My model of oligopoly with product differentiation *does* formally identify these alternative possibilities through the explicit introduction of sales data, i.e. market structure, in the analysis.

Three sources for international price discrimination have been considered: cross-country differences in price elasticities due to product differentiation, differences in quota regimes and differences in the degree of collusive behavior. Large differences in elasticities have been estimated: the domestic firms in France, Germany, the UK and especially in Italy tend to face much lower own-price elasticities than the foreign firms. Significantly binding quota constraints on Japanese firms can be found in France and Italy. The correspondingly high "domestic" market power in France, Germany, Italy and the UK, and the high "Japanese" market power in France and Italy establish the presence of international price discrimination and explain an important part of the observed price differences in the European Community. The remaining part of the observed price differences may follow from systematic differences in the cost of operating in the various markets, including systematic differences in the marginal cost of producing due to country-specific regulations, differences in market-average dealer markups, and errors in measured tax rates or unmeasured temporary exchange rate fluctuations. As an alternative explanation, however, the remaining part of the observed price differences may follow from differences in collusive behavior across countries. Both a high cost of operating and a high degree of collusive behavior may explain the extraordinarily high prices in the United Kingdom.

The empirical results are encouraging and suggest various directions for future research. I summarize those that I believe to be most promising.

(1) More detailed cost analysis: The present analysis has followed the tradition in oligopoly models with product differentiation -- that the marginal cost of a product depends on its "location", as measured empirically by a set of physical characteristics. Eaton and Lipsey (1989) provide a general treatment of this approach. There are two related problems with this approach. First, cost may not be location-specific, but may be common to a subset of products. In the European car industry, cars produced in the same plant will have in common several inputs. Plant-specific data are clearly required to further investigate the role of these inputs in the cost function. Second, and more deeply,

location is itself not an ultimate exogenous variable. Firms choose location based on cost and strategic considerations. Further investigation of this problem requires a more complete model and additional data on the costs of location.

(2) Collusive Behavior: Collusive behavior was approximated in the present paper using conjectural variations. It may be more accurately modelled as an infinitely repeated game with discounting. Data on possible new variables that may appear in this model, such as variables affecting the discount factor, need to be collected for an empirical analysis.

(3) Policy Analysis: The European car market is characterized by many regulations, especially at an international level. My empirical results may be used to analyze the welfare effects of policy changes. For example, in a clear and realistic theoretical model of the European car market, Davidson, Dewatripont, Ginsburgh and Labbe (1989) have analyzed the ambiguous welfare effects of anti-discrimination regulations and linked them to the effects of unification regulations. A similar analysis may be done with my theoretical model, augmented with model simulations using the data and the estimates.

(4) Options Pricing: The charged markups may be relatively small on the base models of the cars. Firms may, however, exercise more market power over the options to the base models. Incorporating options pricing requires explicit modeling, and the collection of additional data.

(5) Intertemporal Competition: Cars compete not only with other cars sold in the same period, but also with cars sold in future periods. This is because of the durable good nature of cars. Again, incorporating these dynamics requires both extra modeling and the collection of new data.

References

Anderson, Simon and Andre De Palma (1992), "Multiproduct Firms: a Nested Logit Approach," *Journal of Industrial Economics,* 3, 261-276.

Anderson, Simon, Andre De Palma and Jacques-Francois Thisse (1989), "Demand for Differentiated Products, Discrete Choice Models, and the Characteristics Approach," *Review of Economic Studies,* 56, 21-35.

Ben-Akiva, Moshe and Steven Lehrman (1985), *Discrete Choice Analysis: Theory and Application to Travel Demand,* MIT Press, 1-390.

Berry, Steve (1991), "Discrete Choice Models of Oligopoly Product Differentiation," Yale University Working Paper.

Berry, Steve, Jim Levinsohn and Ariel Pakes (1993), "Automobile Prices in market Equilibrium," NBER Working Paper.

Bresnahan, Timothy (1981), "Departures from Marginal Cost Pricing in the American Automobile Industry," *Journal of Econometrics,* 17, 201-221.

Bresnahan, Timothy (1987), "Competition and Collusion in the American Automobile Industry: the 1955 Price War," *Journal of Industrial Economics,* 35, 457-482.

Cardell, N.S. (1991), "Variance Components Structures for the Extreme Value and the Logistic Distributions," Washington State University Working Paper.

Caplin, Andrew and Berry Nalebuff (1991), "Aggregation and Imperfect Competition: On the Existence of Equilibrium," *Econometrica,* 59, 26-61.

Commision of the European Communities (1992), "Intra-EC Car Price Differential Report," Brussels.

Davidson, Russell, Mathias Dewatripont, Victor Ginsburgh and Martine Labbe (1989), "On the Welfare Effects of Anti-discrimination Regulations in the EC Car Market," *International Journal of Industrial Organisation,* 7, 205-230.

de Melo and Messerlin (1988), "Price, Quality and Welfare Effects of European VER's on Japanese Autos," *European Economic Review,* 32, p. 1527-1546.

Eaton and Lipsey (1989), "Product Differentiation," *Handbook of Industrial Organisation.*

Feenstra Robert and James Levinsohn (1991), "The Characteristics Approach and Oligopoly Pricing," mimeo.

Flam, Harry (1992), "Product Markets and 1992: Full Integration, Large Gains?" *Journal of Economic Perspectives*, 6, 7-30.

Goldberg, Penny (1991), "Product Differentiation and Oligopoly in International Markets: the Case of the U.S. Automobile Industry," mimeo.

Greenstein, Shane (1992), "From Super-Minis to Super-Computers: Estimating Surplus in the Computing Market," University of Illinois Working Paper.

Griliches, Zvi (1971), "Hedonic Prices for Automobiles: an Econometric Analysis of Quality Change," in *Price Indices and Quality Change,* ed. Zvi Griliches, Cambridge: Harvard University Press.

Kirman, Alan and Schueller Nathalie (1990), "Price Leadership and Discrimination in the European Car Market," *Journal of Industrial Economics*, 34, 69-91.

McFadden, Daniel (1978), "Modelling the Choice of Residential Location," in *Spatial Interaction Theory and Planning Models,* ed. Anders Karlqvist et al, North-Holland Publishing Company.

Mertens, Yves and Victor Ginsburgh (1985), "Product differentiation and Price Discrimination in the European Community: the case of automobiles," *Journal of Industrial Economics*, 34, 151-165.

Pakes, Ariel (forthcoming), "Dynamis Structural Models, Problems and Prospects; Mixed Continuous Discrete Controls and Market Interactions," in *Advances in Econometrics,* ed. J.J. Laffont and C. Jims.

Perloff, Jeffrey and Steven Salop (1985), "Equilibrium with Product Differentiation," *Review of Economic Studies,"* 52, 107-120.

Rosen, Sherwin (1974), "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy,* 82, 34-55.

Sattinger, M. (1984), "Value of an Additional Firm in Monopolistic Competition," *Review of Economic Studies,* 49, 3-13.

Schmalensee, Richard (1985), "Econometric Diagnosis of Competitive Localization," *International Journal of Industrial Organization,* 57-70.

Appendix. Derivation of the transformed demand and pricing equation

As derived in the text, the pricing equation to be taken to the data is (5) or (8), after substituting (19); the demand equation is (18). Unfortunately, as emphasized in the econometric considerations, the error terms ξ_{jm} and ω_{jm} enter these equations nonlinearly. In this Appendix I derive appropriate transformations of the demand and the pricing equations, such that the error terms enter linearly. Because the assumption in the text on the individuals' indirect utility function guaranteed that there are prohibitive arbitrage costs, each market m can be treated independently. Without risk of confusion, I therefore drop the subscript m.

First derive an appropriate transformation of the demand equation. Recall the formulae (15a), (15b) and (15c) for the conditional choice probabilities, or approximately market shares, $s_{j/hg}$, $s_{h/g}$ and s_g. As a special case of s_g, we have the share of the *outside good* in the total market:

$$s_0 = \frac{1}{\sum_{g=0}^{G} D_g^{(1-\sigma_2)}}$$

as found from normalizing δ_0 to zero.

Because $s_{j/h,g}$, $s_{h/g}$ and s_g are positive observed market shares, and not, as in disaggregate models, 0-1 decisions that result in probabilities, we may take logarithms. In particular:

$$\ln(s_g) = (1-\sigma_2)\ln D_g - \ln\Sigma D_g^{(1-\sigma_2)}$$

$$\ln s_0 = -\ln\Sigma D_g^{(1-\sigma_2)}$$

where from (16) and (17):

$$\ln(D_g) = \frac{1-\sigma_1}{1-\sigma_2}\ln D_h - \ln s_{h/g}$$

$$\ln(D_{hg}) = \frac{1}{1-\sigma_1}\delta_j - \ln s_{j/hg}$$

This gives a solution for $\ln s_g$

$$\ln(s_g) = (1-\sigma_2)\left[\frac{1-\sigma_1}{1-\sigma_2}\cdot\left[\frac{1}{1-\sigma_1}\delta_j - \ln s_{j/hg}\right] - \ln s_{h/g}\right] + \ln s_0$$

which may be substituted in

$$\ln s_j = \ln s_{j/hg} + \ln s_{h/g} + \ln s_g$$

to get

$$\ln s_j = \delta_j + \sigma_1 \ln s_{j/hg} + \sigma_2 \ln s_{h/g} + \ln s_0$$

Substituting δ_j for $x_j\beta - \alpha\,(p_j^{\mu}-1)/\mu + \xi_j$ and noting that $\ln s_{h/g} = \ln s_{j/g} - \ln s_{j/h,g}$, we get equation (23a) in the text. In this transformed demand equation ξ_j clearly enters linearly as desired.

Now derive an appropriate transformation of the pricing equation. Drop the variable capturing the percentage deviation of the actual price from the list price, d, and the quota-constraint, λ, to avoid clutter. Consider first the pricing equation without conjectural variations. Assuming for simplicity that a multiproduct firm sells at most one car type per group, the first-order condition for car j is

$$(p_j - mc_j) \cdot \frac{\partial q_j}{\partial p_j} + \sum_{k=1,k\neq j}^{K_f} (p_k - mc_k) \cdot \frac{\partial q_k}{\partial p_j} + q_j = 0$$

where the $\partial q_k/\partial p_k$ all take the form implied by the formula for the corresponding cross-price elasticity (19d) given in the text. After substituting (19d) in the equation it remains impossible to estimate the pricing equation because there are several marginal cost terms, one for each car k produced by the firm, and hence several error terms. To solve this problem the pricing equation is transformed. (This is equivalent to solving the inverted matrix in (7).) First substitute (19d) and rearrange slightly:

$$-\alpha p_j^{\mu-1} s_j (p_j - mc_j) \left[\frac{1}{1-\sigma_1} - \left[\frac{1}{1-\sigma_1} - \frac{1}{1-\sigma_2} \right] s_{j/h,g} - \frac{\sigma_2}{1-\sigma_2} s_{j/g} \right]$$

$$+ \sum_{k=1}^{K_f} (p_k - mc_k) \cdot \left(\alpha p_j^{\mu-1} s_j\right) s_k + s_j = 0$$

Defining r^*_j as the special case of r_j in (24) for which conjectural variations are zero, $\phi=0$, and deviding by $(-\alpha p_j^{\mu-1} s_j)$ we get:

$$(p_j - mc_j) r_j^* - \frac{1}{\alpha} p_j^{1-\mu} = \sum_{k=1}^{K_f} (p_k - mc_k) s_k \tag{25}$$

Because the right hand side is the same for any car sold by the same firm, this implies that for any car sold by the same firm

$$(p_j - mc_j) r_j^* - \frac{1}{\alpha} p_j^{1-\mu} = (p_k - mc_k) r_k^* - \frac{1}{\alpha} p_k^{1-\mu}$$

so that

$$(p_k - mc_k) = \frac{1}{r_k^*} \cdot \left[(p_j - mc_j) r_j^* - \frac{1}{\alpha} p_j^{1-\mu} + \frac{1}{\alpha} p_k^{1-\mu} \right]$$

Substituting this into (25) for all k produced by the firm, we get:

$$(p_j - mc_j) r_j^* - \frac{1}{\alpha} p_j^{1-\mu} = \sum_{k=1}^{K_f} \frac{s_k}{r_k^*} \cdot \left[(p_j - mc_j) r_j^* - \frac{1}{\alpha} p_j^{1-\mu} + \frac{1}{\alpha} p_k^{1-\mu} \right]$$

In this equation only mc_j appears, and all other mc_k are substituted out. Consequently, only one error term remains and estimation is almost possible. Some rearrangements generate:

$$p_j = mc_j + \frac{1}{\alpha} \cdot p_j^{1-\mu} \cdot \frac{1}{r_j^*} \cdot \frac{1 - \sum \frac{s_k}{r_k^*} \cdot \left[1 - \left[\frac{p_k}{p_j} \right]^{1-\mu} \right]}{1 - \sum \frac{s_k}{r_k^*}}$$

This can be rewritten such that only mc_j appears on the right-hand side. Then one can substitute the functional form (1') of mc_j, and log-linearize both sides so that ω_{jm} appears linearly, and estimation of this transformed pricing equation is possible.

Now derive the transformed pricing equation when firms have positive conjectural variations. As in the text, define the conjectural variation dp_l/dp_j as the unit increase in a rival k's price given a unit increase in car j's price. Let $dp_l/dp_j = \phi$ for any rival k belonging to the same group as firm j, and let $dp_l/dp_j = 0$ otherwise. The first-order condition for firm j then is:

$$(p_j - mc_j) \cdot \frac{\partial q_j}{\partial p_j} + \sum_{k=1,k\neq j}^{K_f} (p_k - mc_k) \cdot \frac{\partial q_k}{\partial p_j} + q_j + (p_j - mc_j) \cdot \sum_l \frac{\partial q_j}{\partial p_l} \cdot \frac{dp_l}{dp_j} = 0$$

where the last summation is over all cars that belong to the same group. Substituting the appropriate demand derivatives we get

$$(p_j - mc_j)(-\alpha p_j^{\mu-1} s_j) \left[\frac{1}{1-\sigma_1} - \left[\frac{1}{1-\sigma_1} - \frac{1}{1-\sigma_2} \right] s_{j/h,g} - \frac{\sigma_2}{1-\sigma_2} s_{j/g} - s_j \right] + \sum_{k=1,k\neq j}^{K_f} (p_k - mc_k) \alpha p_j^{\mu-1} s_k s_j + s_j +$$

$$\phi (p_j - mc_j) \left[\sum_{l'} \alpha p_{l'}^{\mu-1} s_j \left[\left[\frac{1}{1-\sigma_1} - \frac{1}{1-\sigma_2} \right] s_{l'/h,g} + \frac{\sigma_2}{1-\sigma_2} s_{l'/g} + s_k \right] + \sum_{l''} \alpha p_{l''}^{\mu-1} s_j \left[\frac{\sigma_2}{1-\sigma_2} s_{l''/g} + s_{l''} \right] \right] = 0$$

where l' denotes any car belonging to the same subgroup as car j, and l'' denotes any car belonging to the same group but to a different subgroup. To simplify, assume $p_j = p_{l'} = p_{l''}$, which is not too unreasonable in the present data set. (Prices differ especially *across* groups, not *within* groups.) This allows us to factor the price out of the second and third summation, so that the (conditional) market shares can be appropriately added up. Rearranging, this yields:

$$-\frac{1}{\alpha} p_j^{1-\mu} + (p_j - mc_k) r_j^* - \sum_{k=1}^{K_f} (p_k - mc_k) s_k - \phi (p_j - mc_j)(r_j^* - 1 + s_g - s_j) = 0$$

This can be rewritten as

$$-\frac{1}{\alpha} p_j^{1-\mu} + (p_j - mc_j)\left((1-\phi) r_j^* + \phi (1 - s_g + s_j)\right) = \sum_{k=1}^{K_f} (p_k - mc_k) s_k \tag{26}$$

Now defining

$$r_j \equiv (1-\phi)r_j^* + \phi(1-s_g+s_j)$$

it is possible to rewrite (26) in the exact same form as (25), so that we get a generalized solution with r_j rather than r^*_j. Attaching the subscript m, then gives the transformed pricing equation (23b) in the text, except for the dropped variables d_m and λ_m.

Footnotes

1. The paper by Mertens and Ginsburgh (1985) is the first product-level study on pricing in the Euroipean car market. However, this study cannot formally identify cost differences from markup differences underlying the observed price differences. Kirman and Schueller (1990) focus on the importance of cost differences. De Melo and Messerlin (1988) look at the effect of import quota. I am not aware of product-level studies that consider price elasticities or collusive behavior.

2. Berry, Levinsohn and Pakes (1993) allow for a more sophisticated notion of localized competition. Goldberg (1993) uses a nested logit model, but she uses disaggregate, household-level data.

3. Let all varables equal zero, except the fixed effects. Call the resulting hypothetical price in market m P_{Im}. Then for Belgium, the reference country, $\ln(p_{Im})=0$, or $p_{Im}=1$. For France, $\ln(p_{Im})=0.01$, or $p_{Im}=1.02$, and similarly for other countries. Multiplying all p_{Im} by 100 gives the hedonic price index.

4. There exists a dual interpretation of the hedonic pricing equation as a marginal value function. However, this interpretation becomes weak in a market where consumers typically buy at most one product.

5. There is evidence that the dealer markup, say τ_m, is indeed calculated as a percentage of the manufacturer's delivered price, p^o_{jm}, so that the observed list price $p_{jm}=(1+\tau_m)p^o_{jm}$, or $p^o_{jm}=p_{jm}/(1+\tau_m)$. If dealer markups would actually be determined differently, say as a percentage of the manufacturer's price-cost margin, the equilibrium pricing conditions wopuld be different and more difficult to estimate.

6. This of course follows from the chosen functional form for marginal cost. Another functional form would have been able to identify both effects, though very weakly.

7. One identifying restriction would be the assumption that all own-price elasticities equal infinity, so that all relative markups equal zero. This then yields the competitive marginal cost interpretation given by Rosen (1974).

8. See especially McFadden (1983), Sattinger (1984), Perloff and Salop (1985), Anderson, De Palma and Thisse (1989), and Caplin and Nalebuff (1991) for recent theoretical contributions.

9. This functional form is known as a Box-Cox transformation.

10. The careful reader may want to check whether this indirect utility specification is consistent with a consumer maximizing utility subject to a budget constraint. However, this is not a simple question, since the goods entering utility, cars, are durables. Hence, quoting Goldberg (1993, p.12), "the expected future income rather than present income, and the life cost of the vehicle instead of the current price should enter the budget constraint". Because of lack of a satisfying theory of durable goods in an oligopoly context with product differentiation, I believe that the flexible specification of price in utility is a useful alternative approach.

11. See Ben-Akiva and Lerman (1985) or Berry (1994) for details.

12. For a derivation and explanation, see for example McFadden (1981).

13. The intuition for multi-product firms, where the cross-price elasticities matter as well, is similar, as may be verified from the solution of the general pricing equation provided later in the text.

14. For an earlier study of the role of import quota on Japanese cars in the European car market, see de Melo and Messerlin (1988). Laussel, Montet and Peguin-Feissolle (1988) use a calibrated model and also study issues on the effects of Japanese competition.

15. See also Bresnahan (1987) on the empirical use of conjectural variations.

16. In general, the demand and pricing equations of discrete choice-models of product differentiation may not contain a closed-form solution for the error terms. In this case, a simulation estimator must be used. For an example, consider the (economically appealing) model of product differentiation developed and estimated by Berry, Levinsohn and Pakes (1993).

17. Existence of a Bertrand-Nash equilibrium has not been shown, although there are indications that an equilibrium does exist. Caplin and Nalebuff (1991) have shown existence of equilibrium in a more general model of product differentiation, for the special case of a one-product firm. Anderson and de Palma (1991) have shown existence of equilibrium in a multiproduct-firm nested logit model, for the special case in which firms are symmetric.

18. Multi-purpose cars, such as the Renault Espace and sports-utility cars, such as the Land Rover were excluded from the sample.

19. Formally, $s_{j/m}=q_{jm}/L_m$, and $s_{0/m}=1-\Sigma_j q_{jm}/L_m$

20. In a more sophisticated model, dynamic aspects of durable good competition may be explicitly incorporated.

21. The t-test statistic for $1/\alpha$, as it appears in the pricing equation, is exactly the same, as can be verified from the delta-method.

22. This may be partly due to the chosen instruments. With a simple least squares estimator, σ_2 was estimated significantly.

23. Similar conclusions were obtained by de Melo and Messerlin (1988).

24. Returns to scale, just like consumer arbitrage, creates a possible cross-market interdependence of the pricing decisions: reducing price in one market increases sales in that market, and therefore reduces (increases) costs in all markets if there are increasing (decreasing) returns to scale. For simplicity, I rule out this possibility by assuming that the national marketing units of the various car manufacturers consider only their national profits in choosing prices.

25. This is because the present specification estimates only two individual-specific taste parameters. In the model of Berry, Levinsohn and Pakes, individual-specific taste parameters on continuous variables such as horsepower and weight are included.

26. The reader may verify how the introduction of the scale variable alters the estimates of many demand and cost coefficients. Apparently, in the nested logit model with no returns to scale many coefficients took over the effects of the omitted scale variable. For example, consider the increased coefficients in the country-of-origin dummies of Germany, US and Japan in the cost equation. Cars from these countries have large *world* market shares and therefore benefit more from returns to scale. Omitting this variable leads to an underestimate of the country-of-origin dummies.

27. The 1992 Intra-EC Car Price Differential Report has calculated that this extra cost equals roughly 100 ECU. For a representative car of 10000 ECU this is only 1 percent. Moreover, this extra cost is likely to enter fixed (development) costs rather than marginal costs.

28. The 1992 Intra-EC Car Price Differential Report suggests this, based on the discussion of its confidential survey data.

29. There is some weak interaction with price due to the multi-product nature of the firm, as can be seen from (23b).

30. The estimated parameters of the nested logit model with conjectural variations are remarkably similar to those of the nested logit model with fixed effects. In addition, the value of the minimized objective function is remarkably similar. This suggests both models cannot reject each other, although a formal nonnested hypothesis test would be desirable to substantiate this claim.

31. This can be seen formally from the pricing equation with conjectural variations. As ϕ_m increases, the car-specific component becomes less important, and the group-specific component (including $s_{g/m}$) becomes more important.

TABLE I
Characteristics of the various markets

	VAT in %	Wage in ECU	Sales in 1000	C1 in %	C4 in %	C7 in %	Foreign Share	Japanese Share	
								actual	quota
Belgium	25-33	18.7	474	16.5	52.7	73.8	100	20.1	-
France	28	15.7	2309	32.8	78.3	92.2	38.1	3.4	3.0
Germany	14	23.6	3041	28.8	63.6	78.8	30.2	15.9	15.0
Italy	19-38	14.5	2348	57.6	84.8	95.1	42.2	2.0	1.1
UK	24.6	9.7	2009	26.5	63.8	79.7	70.5	11.7	11.0

TABLE II The Hedonic Pricing Equation		
Fixed Effects (relative to Belgium)	France	0.016 (0.025)
	Germany	0.091 (0.024)
	Italy	0.145 (0.025)
	UK	0.183 (0.024)
Foreign Firm Effect		0.006 (0.019)
Technical Characteristics	Constant	6.745 (0.251)
	HP	0.107 (0.005)
	Weight	0.427 (0.085)
	Width	0.865 (0.137)
	Height	-0.219 (0.117)
Country of Origin	France	0.140 (0.025)
	Germany	0.224 (0.025)
	Italy	0.082 (0.025)
	UK	0.057 (0.033)
	US	0.125 (0.027)
	Japan	0.075 (0.022)

TABLE III The Hedonic Price Index	
Belgium	100
France	102
Germany	110
Italy	116
UK	120

TABLE IV
The Logit versus the Nested Logit model
Instrumental Variable Estimates
512 observations

		Logit	Nested Logit
Parameters in both demand and pricing equation			
	μ	0	0
	α	4.510 (0.567)	3.854 (0.302)
	σ_1	0	0.667 (0.071)
	σ_2	0	0.027 (0.200)
Other parameters appearing in demand equation			
Fixed Effects (relative to Belgium)	France	1.158 (0.233)	0.228 (0.161)
	Germany	1.266 (0.222)	0.082 (0.206)
	Italy	1.185 (0.239)	0.394 (0.155)
	UK	1.987 (0.249)	0.928 (0.177)
Foreign Firm Disadvantage		-1.664 (0.176)	-0.922 (0.159)
Technical Characteristics	Constant	-20.653 (11.529)	-25.839 (6.257)
	HP	1.862 (0.659)	1.493 (0.345)
	Weight	-0.287 (0.923)	-0.074 (0.500)
	Width	15.919 (2.280)	8.662 (1.414)
	Height	-5.909 (1.545)	1.953 (1.174)
Country of Origin	France	1.304 (0.263)	0.656 (0.153)
	Germany	2.336 (0.285)	1.289 (0.195)
	Italy	0.416 (0.240)	0.322 (0.131)
	UK	0.472 (0.311)	0.489 (0.166)
	US	1.417 (0.271)	0.799 (0.157)
	Other country	-1.664 (0.176)	0.231 (0.122)

TABLE IV (continued)
Logit versus Nested Logit
Instrumental Variable Estimates
512 observations

		Logit	Nested Logit
Other parameters appearing in pricing equation			
Fixed Effects (relative to Belgium)	France	-0.009 (0.026)	-0.026 (0.027)
	Germany	0.086 (0.025)	0.064 (0.026)
	Italy	0.118 (0.026)	0.095 (0.027)
	UK	0.163 (0.026)	0.139 (0.027)
Foreign Firm Disadvantage		0.010 (0.019)	0.033 (0.019)
Technical Characteristics	Constant	6.607 (0.253)	6.705 (0.253)
	HP	0.105 (0.005)	0.102 (0.005)
	Weight	0.487 (0.084)	0.487 (0.085)
	Width	0.816 (0.135)	0.820 (0.136)
	Height	-0.265 (0.116)	-0.219 (0.118)
Country of Origin	France	0.139 (0.025)	0.138 (0.025)
	Germany	0.217 (0.025)	0.219 (0.025)
	Italy	0.081 (0.024)	0.078 (0.025)
	UK	0.057 (0.032)	0.059 (0.033)
	US	0.120 (0.027)	0.118 (0.027)
	Other Country	0.035 (0.030)	0.050 (0.030)
Country-specific quota on Japanese firms	France	564.2 (264.3)	487.2 (313.9)
	Germany	52.9 (290.7)	3.550 (339.2)
	Italy	824.2 (333.1)	770.8 (399.0)
	UK	407.2 (265.3)	340.1 (312.3)

TABLE V
Instrumental Variable Estimates of Nested Logit Model
with returns to scale
512 observations

		base	μ free	C.V.
Parameters appearing in both demand and pricing equation				
	μ	0	-0.287 (0.033)	0
	α	3.312 (0.271)	85.903 (30.474)	3.205 (0.268)
	σ_1	0.578 (0.065)	0.483 (0.069)	0.570 (0.065)
	σ_2	0.017 (0.172)	-0.049 (0.166)	-0.028 (0.174)
Other parameters appearing in demand equation				
Fixed Effects (relative to Belgium)	France	0.317 (0.158)	0.555 (0.180)	0.262 (0.153)
	Germany	0.245 (0.197)	0.466 (0.215)	0.195 (0.193)
	Italy	0.431 (0.152)	0.780 (0.179)	0.346 (0.144)
	UK	0.947 (0.172)	1.577 (0.216)	0.873 (0.163)
Foreign Firm Disadvantage		-1.010 (0.145)	-1.156 (0.154)	-1.005 (0.145)
Technical Characteristics	Constant	-31.162 (6.080)	89.9 (70.523)	-31.476 (6.083)
	HP	0.774 (0.297)	2.532 (0.463)	0.707 (0.297)
	Weight	-0.221 (0.490)	0.577 (0.561)	-0.327 (0.489)
	Width	10.663 (1.374)	14.543 (1.593)	10.752 (1.372)
	Height	0.685 (1.120)	-0.690 (1.232)	0.651 (1.113)
Country of Origin	France	0.606 (0.149)	1.159 (0.189)	0.596 (0.148)
	Germany	1.256 (0.183)	1.976 (0.224)	1.249 (0.182)
	Italy	0.272 (0.129)	0.558 (0.156)	0.260 (0.129)
	UK	0.442 (0.166)	0.694 (0.195)	0.438 (0.166)
	US	0.775 (0.153)	1.301 (0.192)	0.775 (0.153)
	Other Country	0.180 (0.121)	0.428 (0.144)	0.160 (0.121)

TABLE V (continued)
Instrumental Variable Estimates of Nested Logit Model
with returns to scale
512 observations

		base	μ free	C.V.
Other parameters appearing in pricing equation				
Fixed Effects (relative to Belgium)	France	-0.061 (0.029)	-0.039 (0.028)	-1.470 (1.025)
	Germany	0.060 (0.028)	0.079 (0.027)	0.371 (0.160)
	Italy	0.047 (0.030)	0.069 (0.029)	0.177 (0.215)
	UK	0.118 (0.029)	0.138 (0.028)	0.607 (0.110)
Foreign Firm Disadvantage		0.077 (0.022)	0.059 (0.021)	0.086 (0.021)
Returns to Scale		-0.143 (0.016)	-0.118 (0.011)	-0.145 (0.012)
Technical Characteristics	Constant	7.779 (0.286)	7.588 (0.277)	7.725 (0.287)
	HP	0.074 (0.005)	0.077 (0.005)	0.075 (0.005)
	Weight	0.071 (0.100)	0.119 (0.095)	0.073 (0.100)
	Width	1.902 (0.172)	1.694 (0.170)	1.889 (0.173)
	Height	-0.555 (0.131)	-0.484 (0.128)	-0.567 (0.132)
Country of Origin	France	0.190 (0.028)	0.178 (0.027)	0.195 (0.028)
	Germany	0.356 (0.029)	0.326 (0.029)	0.357 (0.029)
	Italy	0.069 (0.027)	0.069 (0.027)	0.069 (0.027)
	UK	0.043 (0.036)	0.044 (0.036)	0.046 (0.036)
	US	0.247 (0.032)	0.225 (0.031)	0.253 (0.031)
	Other Country	0.126 (0.031)	0.125 (0.029)	0.120 (0.031)
country-specific quota on Japanese firms	France	914.1 (259.7)	719.1 (248.2)	1019.5 (282.4)
	Germany	152.0 (297.0)	-54.2 (282.0)	185.0 (282.4)
	Italy	1709.1 (315.9)	1540.6 (309.1)	1762.7 (321.8)
	UK	433.0 (270.4)	176.6 (255.6)	396.6 (252.8)

Table VI
Price Elasticities for Selected Cars
for Base Specification

	Germany				Italy			
	Effect of car's % price increase on							
	its own % demand increase	% demand increase of its competitor from			on its own % demand decrease	% demand increase of its competitor from		
		same subgroup	same group	other group		same subgroup	same group	other group
Fiat Uno	6.844	1.735	0.054	0.048	5.053	4.575	0.453	0.435
Ford Fiesta	5.809	3.507	0.110	0.098	6.452	2.342	0.161	0.154
Nissan Micra	7.310	0.938	0.029	0.026	7.849	0.015	0.001	0.001
Renault 5	7.342	0.883	0.027	0.024	7.171	1.144	0.078	0.075
Fiat Tipo	7.284	0.979	0.035	0.033	4.424	5.817	0.265	0.244
Ford Escort	7.237	1.027	0.080	0.075	7.356	0.854	0.033	0.031
Renault 19	6.953	1.543	0.055	0.052	6.929	1.581	0.062	0.057
Toyota Corolla	7.121	1.257	0.045	0.042	7.841	0.029	0.001	0.001
VW Golf	5.175	4.442	0.346	0.325	5.919	3.300	0.129	0.119
Lancia Dedra	7.719	0.240	0.004	0.004	6.131	2.970	0.075	0.066
Mazda 626	6.563	2.239	0.040	0.036	7.853	0.008	0.000	0.000
Opel Vectra	6.458	2.337	0.154	0.141	7.472	0.660	0.021	0.019
Peugeot 405	7.212	1.118	0.020	0.018	7.395	0.792	0.025	0.022
Audi 80	6.450	2.351	0.155	0.142	6.716	1.953	0.063	0.055
BMW 3-series	6.009	3.162	0.104	0.085	6.540	2.291	0.025	0.014
Citroen XM	6.978	1.535	0.010	0.008	7.078	1.355	0.015	0.008
Fiat Croma	7.386	0.822	0.005	0.004	3.330	7.901	0.043	0.024
Mercedes 200	5.716	3.632	0.159	0.135	6.020	3.190	0.041	0.028
BMW 7-series	6.131	2.996	0.040	0.019	5.193	4.646	0.031	0.002

Table VII
Relative Markups of Selected Cars
for Base Specification

	Belgium	France	Germany	Italy	UK
Fiat Uno	0.134	0.150	0.162	0.383	0.140
Ford Fiesta	0.137	0.148	0.172	0.155	0.187
Nissan Micra	0.142	0.299	0.172	0.390	0.214
Renault 5	0.137	0.176	0.136	0.141	0.134
Fiat Tipo	0.133	0.143	0.139	0.340	0.133
Ford Escort	0.134	0.142	0.138	0.136	0.174
Renault 19	0.141	0.200	0.144	0.144	0.136
Toyota Corolla	0.158	0.252	0.224	0.265	0.206
VW Golf	0.147	0.166	0.193	0.169	0.148
Lancia Dedra	0.130	0.135	0.131	0.301	0.128
Mazda 626	0.145	0.250	0.210	0.236	0.189
Opel Vectra	0.137	0.138	0.155	0.134	0.166
Peugeot 405	0.148	0.202	0.148	0.143	0.157
Audi 80	0.153	0.161	0.204	0.178	0.141
BMW 3-series	0.139	0.165	0.166	0.153	0.164
Citroen XM	0.147	0.188	0.159	0.147	0.139
Fiat Croma	0.130	0.138	0.135	0.300	0.128
Mercedes 200	0.181	0.178	0.223	0.195	-
BMW 7-series	0.164	0.162	0.163	0.193	0.229

Table VIII
Lerner-indices
for Nested Logit Specifications

		Belgium	France	Germany	Italy	UK
Lerner-indices						
	base	0.145	0.177	0.178	0.268	0.167
	μ free	0.093	0.110	0.115	0.149	0.111
	C.V.	0.153	0.104	0.240	0.310	0.263

TABLE IV bis The Logit versus the Nested Logit model Least Squares Estimates 512 observations			
		Logit	Nested Logit
Parameters in both demand and pricing equation			
	μ	0	0
	α	3.198 (0.350)	3.171 (0.168)
	σ_1	0	0.849 (0.020)
	σ_2	0	0.366 (0.061)
Other parameters appearing in demand equation			
Fixed Effects (relative to Belgium)	France	1.091 (0.226)	0.077 (0.117)
	Germany	1.277 (0.216)	0.035 (0.121)
	Italy	1.043 (0.229)	0.233 (0.117)
	UK	1.741 (0.229)	0.686 (0.119)
Foreign Firm Disadvantage		-1.646 (0.172)	-0.580 (0.092)
Technical Characteristics	Constant	-30.097 (10.745)	-33.412 (5.332)
	HP	0.703 (0.504)	0.870 (0.245)
	Weight	-1.028 (0.877)	-0.215 (0.435)
	Width	16.854 (2.196)	7.345 (1.113)
	Height	-5.426 (1.503)	4.432 (0.780)
Country of Origin	France	1.033 (0.240)	0.359 (0.120)
	Germany	1.948 (0.248)	0.764 (0.126)
	Italy	0.267 (0.229)	0.281 (0.114)
	UK	0.354 (0.301)	0.464 (0.149)
	US	1.213 (0.256)	0.541 (0.127)
	Other country	-0.167 (0.210)	0.302 (0.105)
Std Dev of ξ_{jm}		1.254	0.622

TABLE IV bis (continued)
Logit versus Nested Logit
Least Squares Estimates
512 observations

		Logit	Nested Logit
Other parameters appearing in pricing equation			
Fixed Effects (relative to Belgium)	France	-0.006 (0.026)	-0.014 (0.026)
	Germany	0.082 (0.025)	0.067 (0.025)
	Italy	0.128 (0.025)	0.114 (0.026)
	UK	0.162 (0.025)	0.146 (0.026)
Foreign Firm Disadvantage		0.014 (0.019)	0.029 (0.019)
Technical Characteristics	Constant	6.429 (0.255)	6.698 (0.254)
	HP	0.107 (0.005)	0.104 (0.005)
	Weight	0.460 (0.084)	0.455 (0.086)
	Width	0.825 (0.135)	0.844 (0.137)
	Height	-0.233 (0.116)	-0.200 (0.118)
Country of Origin	France	0.138 (0.025)	0.140 (0.025)
	Germany	0.217 (0.025)	0.223 (0.025)
	Italy	0.080 (0.024)	0.078 (0.025)
	UK	0.058 (0.032)	0.056 (0.033)
	US	0.120 (0.027)	0.122 (0.027)
	Other Country	0.048 (0.028)	0.063 (0.030)
country-specific quota on Japanese firms	France	353.9 (211.6)	290.2 (300.9)
	Germany	46.3 (230.6)	88.0 (317.1)
	Italy	270.9 (279.8)	92.9 (401.0)
	UK	318.4 (206.3)	293.3 (290.7)
Std Dev of ω_{jm}		0.135	0.137

TABLE V bis
Least squares Estimates of Nested Logit Model with Returns to Scale
515 observations

		base	μ free	C.V.
Parameters appearing in both demand and pricing equation				
	μ	0	-0.243 (0.024)	0
	α	3.977 (0.156)	56.772 (13.219)	3.753 (0.330)
	σ_1	0.770 (0.020)	0.722 (0.020)	0.783 (0.020)
	σ_2	0.192 (0.059)	0.086 (0.058)	0.201 (0.059)
Other parameters appearing in demand equation				
Fixed Effects (relative to Belgium)	France	0.156 (0.127)	0.278 (0.156)	0.075 (0.120)
	Germany	0.037 (0.130)	0.135 (0.156)	-0.038 (0.125)
	Italy	0.353 (0.127)	0.569 (0.156)	0.202 (0.120)
	UK	0.873 (0.128)	1.285 (0.156)	0.753 (0.120)
Foreign Firm Disadvantage		-0.739 (0.099)	-0.836 (0.120)	-0.673 (0.095)
Technical Characteristics	Constant	-28.062 (5.746)	119.683 (32.460)	-29.221 (5.614)
	HP	1.276 (0.233)	2.239 (0.249)	1.163 (0.233)
	Weight	0.572 (0.460)	1.484 (0.541)	0.341 (0.452)
	Width	8.062 (1.198)	11.753 (1.468)	7.955 (1.173)
	Height	2.611 (0.833)	1.589 (1.006)	2.971 (0.817)
Country of Origin	France	0.588 (0.129)	0.963 (0.158)	0.541 (0.126)
	Germany	1.165 (0.134)	1.677 (0.161)	1.083 (0.131)
	Italy	0.366 (0.124)	0.582 (0.154)	0.351 (0.121)
	UK	0.535 (0.164)	0.740 (0.203)	0.524 (0.159)
	US	0.725 (0.138)	1.096 (0.171)	0.698 (0.135)
	Other Country	0.351 (0.114)	0.609 (0.141)	0.325 (0.111)

TABLE V bis (continued)
Least Squares Estimates of Nested Logit Model
with Returns to Scale
512 observations

		base	μ free	C.V.
Other parameters appearing in pricing equation				
Fixed Effects (relative to Belgium)	France	-0.022 (0.027)	-0.017 (0.026)	-2.277 (3.481)
	Germany	0.071 (0.026)	0.075 (0.025)	0.495 (0.154)
	Italy	0.103 (0.027)	0.105 (0.026)	0.558 (0.128)
	U.K.	0.144 (0.026)	0.148 (0.026)	0.783 (0.057)
Foreign Firm Disadvantage		0.044 (0.020)	0.041 (0.020)	0.061 (0.018)
Returns to scale		-0.054 (0.005)	-0.055 (0.004)	-0.053 (0.005)
Technical Characteristics	Constant	7.141 (0.261)	7.154 (0.253)	7.148 (0.259)
	HP	0.085 (0.005)	0.083 (0.004)	0.089 (0.005)
	Weight	0.389 (0.087)	0.385 (0.082)	0.377 (0.087)
	Width	1.257 (0.145)	1.266 (0.140)	1.226 (0.144)
	Height	-0.415 (0.121)	-0.403 (0.118)	-0.399 (0.120)
Country of Origin	France	0.160 (0.026)	0.158 (0.026)	0.166 (0.026)
	Germany	0.280 (0.026)	0.280 (0.026)	0.278 (0.026)
	Italy	0.080 (0.026)	0.080 (0.026)	0.083 (0.025)
	U.K.	0.054 (0.034)	0.053 (0.034)	0.058 (0.034)
	U.S.	0.170 (0.029)	0.171 (0.028)	0.175 (0.028)
	Other Country	0.107 (0.027)	0.111 (0.026)	0.096 (0.027)
country-specific quota on Japanese firms	France	372.0 (250.1)	332.6 (192.8)	386.2 (265.2)
	Germany	75.1 (266.6)	65.7 (204.7)	133.2 (260.4)
	Italy	450.4 (324.3)	491.7 (248.4)	564.2 (310.9)
	UK	240.4 (246.1)	164.8 (190.4)	241.6 (227.3)

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