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ABSTRACT

The Evolution of Price Discrimination in the European Car Market

Pinelopi Koujianou Goldberg, Frank Verboven*

Car prices in Europe are characterized by large and persistent differences across countries. The purpose of this paper is to document and explain this price dispersion. Using a panel data set extending from 1980 to 1993, we first demonstrate two main facts concerning car prices in Europe: (1) The existence of significant differences in quality adjusted prices across countries, with Italy and the U. K. systematically representing the most expensive markets. (2) Substantial year-to-year volatility that is to a large extent accounted for by exchange rate fluctuations and the incomplete response of local currency prices to these fluctuations. These facts are analyzed within the framework of a multiproduct oligopoly model with product differentiation. The model identifies three potential sources for the international price differences: price elasticities generating differences in markups, costs, and import quota constraints. Local currency price stability can be attributed either to the presence of a local component in marginal costs, or to markup adjustment that is correlated with exchange rate volatility; the latter requires that the perceived elasticity of demand is increasing in price. We find that the primary reason for the higher prices in Italy is the existence of a strong bias for domestic brands that generates high markups for the domestic firm (Fiat). In the U. K. higher prices are mainly attributed to better equipped cars and/or differences in the dealer discount practices. The import quota constraints are found to have a significant impact on Japanese car prices in Italy, France and the U. K.. With respect to local currency price stability, 2/3 of the documented price inertia are attributed to local costs, and 1/3 to markup adjustment that is indicative of price discrimination. Based on these results we conjecture that the EMU will substantially reduce the year-to-year volatility observed in the car price data, but without further measures to increase European integration, it will not completely eliminate existing cross-country price differences.

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ZUSAMMENFASSUNG

Die Entwicklung der Preisdiskriminierung im europäischen Automobilmarkt

Die Autopreise in Europa sind durch große und beständige Unterschiede zwischen Ländern gekennzeichnet. Ziel dieses Beitrages ist es, diese Preisstreuung zu erklären. Anhand eines Paneldatensatzes für den Zeitraum von 1980 bis 1993 wird erstens aufgezeigt, daß signifikante Unterschiede in qualitätsangepaßten Peisen zwischen den Ländern bestehen, wobei Italien und Großbritannien die teuersten Märkte aufweisen. Zweitens lassen sich beträchtliche Schwankungen von Jahr zu Jahr feststellen, die vor allem auf Wechselkursveränderungen und unvollständige Reaktionen bei der lokalen Preissetzung zurückzuführen sind. Diese Sachverhalte werden im Rahmen eines Mehrprodukt-Oligopol-Modells mit Produktdifferenzierung analysiert. Das Modell identifiziert drei potentielle Quellen für internationale Preisunterschiede: Preiselastizitäten, die unterschiedliche Gewinnspannen erzeugen, Kosten- und Importquotenbeschränkungen. Inwieweit diese Ursachen im einzelnen zutreffen, wird für die verschiedenen Länder ausführlich erörtert. Insgesamt lassen die Ergebnisse darauf schließen, daß sich im Gefolge der europäischen Währungsunion die von Jahr zu Jahr zu beobachtenden Schwankungen der Automobilpreise verringern dürften; sie verdeutlichen aber auch, daß ohne weitere Maßnahmen in Richtung europäische Integration die existierenden Preisunterschiede zwischen den einzelnen Ländern nicht vollständig verschwinden werden.

1. Introduction

Car prices in Europe are characterized by large and persistent differences across countries. Figures 1a and 1b plot for each car model the maximum percentage and absolute bilateral price difference observed across five distinct markets (Belgium, France, Germany, Italy and the United Kingdom) against the average across the five markets price of the model; all prices are pre-tax, and expressed in a common currency, ECUs. The price dispersion appears to be enormous; on average, the maximum price differential is around 30% of the car price, implying that the price of a 10,000 ECU (approximately $10,000) car can vary by as much as 3,000 ECUs (or $3,000) between two countries. The percentage differences are fairly constant in the price of a car, so that the absolute price differences become even larger as we move towards more expensive models.[1] Moreover, there seems to be no tendency at all (at least not on the basis of the raw data plots) for the price differences to decline over time; in 1993, the price dispersion is at least as pronounced as in 1980.

These price differences have been the focus of intense public debate in Europe. Consumer organizations argue that the price dispersion is the result of geographical market segmentation, allowing for anti-competitive price discriminating practices; such organizations closely monitor the evolution of price differences, and prefer those to be small (see, for example, the reports of the Bureau of European Consumers Unions (BEUC) in 1981, 1986, 1989, 1992). Industry insiders, on the other hand, defend the high cross-country price differences as the result of exchange rate fluctuations and tax policies. Empirically, the price dispersion in the European car market coincides with both large exchange rate movements and substantial, evolving cross-country differences in value-added taxes. Proponents of this view consider the impending currency union to be the solution to the problem. "You can only have price harmony if you have a common currency", is an industry representative quoted in the New York Times ((New York Times, Jan. 17, 1996). "Should the single currency arrive", continue the New York Times, "... Europe is expected to more closely resemble the United States. Prices would vary slightly region by region, reflecting income differences, shipping costs and other variables, but there would be fewer sharp differences". This view, however, contrasts with the findings of empirical studies that have attributed the price dispersion to differences in demand elasticities across national markets (Mertens and Ginsburgh (1985)), differences in concentration (Mertens and Ginsburgh (1985), Flam and Nordstrom (1994)), lack of uniform taxation on the value added (Gual (1993)), and differences in import quota constraints (de Melo and Messerlin (1988), Gual

[1] Graphs of the standard deviation and coefficient of variation of car prices display similar patterns.

(1993), Flam and Nordstrom (1994)). It also contrasts with the car manufacturers' active efforts to keep European markets geographically segmented, by maintaining the selectivity of the distribution system, and preventing their dealers from selling to foreign customers (see the discussion in the next section).

While the source of price disparities may be a source of disagreement among auto experts, consensus seems to exist that this is an important issue in the European Community. The perhaps most provocative statement concerning the issue can be found in Smith and Venables (1988), who claimed that the most substantial welfare gains associated with European integration would arise not from the removal of trade barriers, but from the elimination of firms' ability to price discriminate across markets. The Commission of the European Communities also views price differentials as a potential threat to the European market integration policies. Since 1992, it has conducted price investigations at a bi-annual basis to monitor the evolution of international price differences. The Commission has repeatedly found price differences far in excess of the 12% that were allowed in return for granting manufacturers a restrictive system of selective and exclusive distribution. Implicit in the effort to keep price differences small is the presumption that price discrimination is welfare reducing. The latter is rather controversial, given that economic theory suggests that the welfare effects of price discrimination are ambiguous. Against this background, and with the European Monetary Union close at hand, it seems particularly important to understand the sources of price dispersion in the European markets.

This paper is part of a bigger project exploring the relationship between price discrimination, economic integration and welfare in Europe. Our goals in this paper are twofold; describe the pattern of price dispersion in five major European markets in the 1980's and early 1990's to obtain the basic "facts" that demand explanation; and identify the sources of cross- country price differentials within the framework of an oligopoly model. In a sequel paper we use the estimation results from this paper to explore the implications of price discrimination for economic welfare, and address the effects of various policy changes such as monetary union, tax harmonization, and price regulations (e.g, strict enforcement of the European Commission's 12% rule) through simulations.

Given the large number of existing studies on price dispersion in the European car market, it is perhaps useful to point out which features of our analysis distinguish the current work from previous research. We believe that our approach improves on earlier work in three respects. First, in order to adjust for product quality differences that would potentially explain cross-country price differences, we constructed a major database containing extremely detailed disaggregate information on prices, sales, characteristics and production location of approximately 300 models sold in the five markets under consideration in the period 1980-1993. In addition to allowing us to control for quality differences, the disaggregate data offer the advantage of enabling us to conduct the analysis at the firm level, thus avoiding controversial aggregation assumptions. Second, because our data set has a relatively long time dimension (14 years), we can explicitly address the effects of exchange rate volatility on price dispersion; previous studies often based their conclusions on a single year cross-section, thus abstracting from the role of exchange rates. The third advance is that we analyze the data systematically within the framework of an oligopoly model with product differentiation. This framework is needed in order to conduct counterfactual policy simulations. In addition, it enables us to ultimately address the question whether price differences are the result of cost differences or price discrimination; and if the latter is the case, further investigate what the sources of price discrimination are. One interpretation difficulty that often arises in the context of earlier studies is that while these studies unambiguously establish correlations between exchange rates, tax differences, import quotas and cross-country price differentials, it is not clear whether these correlations are indicative of cross-country cost differences or price discrimination. This problem is particularly acute in the context of exchange rates. Because price dispersion is empirically highly correlated with nominal exchange rate volatility, price differences are often "justified" as being due to the high "costs" associated with an overvalued currency. But the response of prices to exchange rates (or the lack thereof) may itself reflect markup adjustment and be therefore indicative of price discrimination.[2]

We start our analysis by documenting the existence of price dispersion during our sample period and examining whether it appears to be persistent, reflecting the importance of structural factors, or temporary, due, for example, to exchange rate realignments, that are not passed onto prices in the short run. Through a series of reduced form regressions we investigate whether quality adjusted price differences are systematically related to factors such as exchange rate fluctuations and tax differences. The reduced form estimation combines hedonic regression techniques with the pricing-to-market literature. In this part of the analysis we also examine whether quality adjusted prices across European countries appear to converge over time, as European integration progresses, and the year for the realization of the European Monetary Union (EMU) approaches; if so, what role do exchange rates play in this process?

[2]This is a point that has convincingly been made in the "pricing-to-market" literature, and we will return to it in the next section.

We next turn into a more systematic investigation of price differences. To this end, we develop and estimate a model of oligopoly with product differentiation that incorporates exchange rate fluctuations and tax differences. This framework allows us to decompose the equilibrium price of each vehicle make into two components: its marginal cost and a markup. The markup depends in turn on the demand side of the market (own- and cross-price elasticities), the extent of collusion, and restrictions on demand, such as import quota constraints. Our approach allows us not only to estimate the markup, but also decompose it to its respective determinants to understand the sources of price discrimination. We are particularly interested in identifying the role of local competition in explaining the cross-country price differentials. Are higher prices in some markets generated by strong preferences for domestic brands?

To evaluate the claim that price differences are generated by nominal exchange rate volatility, particular attention is paid throughout the analysis to the role of exchange rates in price determination. An analysis of the effects of exchange rates on equilibrium prices and quantities is equivalent to a comparative statics exercise in costs. Exchange rate fluctuations can (plausibly) be treated as exogenous shocks that shift the production costs of firms of a particular nationality relative to the costs of the other suppliers in the market. Such shocks rotate the supply curves of the firms facing currency fluctuations, helping us to identify the demand elasticities and markups in the relevant markets. Given the focus of our analysis on *price* differences across markets, we are particularly interested in the effects of exchange rate fluctuations on *prices*. Theoretical work in the area has shown that this response is related to the curvature of the demand schedule. This has often been viewed as unsettling[3], given that it implies a strong dependence of the results on particular functional form assumptions concerning the demand function. Rather than imposing such assumptions a-priori, we estimate a flexible demand system, and then examine whether our parameter estimates imply a curvature that is consistent with the observed price response to exchange rate fluctuations. In addition, we investigate the hypothesis that the incomplete response of local currency prices to exchange rate fluctuations is due to the existence of a local component in marginal cost.

Methodologically, our approach is closest to the one adopted in Verboven (1996) who studied the European auto market in 1990. His analysis was however limited by the fact that the focus on a single year could not – by construction – address the high correlation between international price differences and nominal exchange rate volatility, which seems to be one of the most characteristic, if not defining, features of price dispersion in international markets.

[3] See, for example, the discussion in Krugman (1987).

Indicatively, in 1990, the most "expensive" countries for automobile purchases were the United Kingdom and Italy; by 1996, this relationship was completely reversed, and the major exchange rate realignments in 1992 seem to have played an important role in this reversal.[4]

To preview our results, we document large and persistent cross-country differences of quality adjusted prices, with the U.K. and Italy being systematically more expensive than the other markets for almost the entire sample period. While the ranking of the countries remains relatively stable during the 14 years in our sample, the magnitude of the price differentials exhibits substantial volatility from year to year. This volatility appears to be highly correlated with exchange rate fluctuations. The descriptive analysis strongly suggests the presence of local price stability during exchange rate realignments. This stability is not short-term, due for example to temporary nominal rigidities; it is also characteristic of the long run price response to exchange rate changes.

The estimation results from our empirical model help us identify the factors generating the price differentials and the local price stability. The cross-country price differences are attributed to cost differences, varying degrees in the restrictiveness of quota constraints, and the presence of a strong bias for domestic brands in consumer preferences. This bias implies that domestic firms face lower price elasticities of demand and charge higher markups. Accordingly, markets in which domestic firms occupy a dominant position, are characterized by higher prices; this seems to be true in Italy, where Fiat is almost a monopoly. These findings explain why Belgium, the only country in our sample in which there are no domestic brands and no import constraints, is characterized by lower prices.

With respect to local currency price stability, we find that a surprisingly large fraction of it can be attributed to the existence of a local component in marginal costs. Markup adjustment, that is correlated with exchange rate volatility, also seems to play an important role. Our results indicate that the perceived price elasticities of demand are increasing in price; the percentage loss in market share resulting from a 1% increase in the price of a car is larger than the percentage gain achieved through a 1% price drop; this translates to a tendency for firms to keep prices relatively stable when faced with cost shocks. We also find some evidence that the smaller the market share is, the more pronounced this convexity is. This is rather intuitive: a firm occupying a market niche has a lot to lose from a price increase, but little to gain from a price decrease. Hence, when faced with a cost shock (such as an exchange rate change), it will

[4] By 1998, however, the U.K. had become the most expensive destination again.

keep its price relatively stable, and absorb the shock by adjusting its markup.

The remainder of the paper is organized as follows. The next section provides an institutional analysis of the European auto market and examines the factors contributing to geographical market segmentation. In section 3 we take a first look at the data. Section 4 discusses the empirical model. Section 5 discusses the estimation procedure and the instruments. Section 6 presents our empirical results, and section 7 concludes.

2. Geographical market segmentation and market structure

Despite the removal of all tariffs within the European Community (European Union, now) in 1968, several non-tariff barriers remained for many years, while other barriers have even been introduced on a systematic basis in more recent years. Apart from "common" transportation and information costs and several bureaucratic formalities, restrictions are related to the differing national systems of type approval, the distribution system, and the requirement of national registration.

A first obstacle to cross-border trade is caused by the differing national systems of type approval. Traditionally, each country could adopt its own set of requirements for new car models. A European framework Directive in 1970 set out a list of 44 "essential requirements" that needed harmonization throughout the Community.[5] Although many type approval directives emanated from this framework Directive, the process has been very slow. The last three directives (covering windscreens, tires and towing weights) have only been agreed upon in 1992, as part of the "1992 Program" for completion of the common market. Around the same time, an agreement was also finally reached on common standards for exhaust emissions; these had become a major element in specification differences across European countries and had not been foreseen in the original 1970 framework Directive. For a long time countries had the option of allowing their national standards to co-exist with the European directives; most countries made use of this option. By 1987, only Italy had adopted the European directives as the single local standard (see BEUC, 1987). The harmonized type approval directives eventually became mandatory, and fully replaced the national systems in 1995.

The enduring existence of national type approval rules formed a major impediment to consumers seeking to purchase a car abroad.[6] Costly modifications of the imported vehicle were

[5] Directive 70/156, Official Journal of the European Communities, nr. L42 of 23 Febr. 1970.

[6] For the organized official importers, problems associated with differing national standards are, of course,

often needed. Moreover, in most countries the job of checking and certifying the conformity of an imported car was entrusted to the official importers. There is no doubt that this procedure enabled them to control and monitor the cross-country trade in the cars they were selling (BEUC, 1982). The granting of a certificate often took several weeks, involved costly trips, and required fees that bore no relationship to the services provided.[7]

A second major obstacle to cross-border trade stems from the system of selective and exclusive distribution. Article 85(1) of the Treaty of Rome prohibits agreements that prevent, restrict, or distort competition within the European Union. However, several exemptions are allowed, provided that the imposed restrictions have beneficial effects that cannot be realized otherwise. For many years, such restrictions were implemented through a set of bilateral contracts between suppliers and dealers. Many manufacturers instructed their dealers (threatening to withdraw their concessions) not to sell to independent resellers, in particular if the purchase was intended for export. Discrimination against resellers occurred in several subtle forms: excessive delivery lags, high deposit requirements, reservations to provide guarantee outside the country of purchase, and higher prices (BEUC, 1981 and 1982). In 1984, a "block" or "group" exemption to article 85(1) was installed, Regulation 123/85; it specified in detail the potentially restrictive arrangements that are legally permitted in agreements between car suppliers and their dealers.[8] The Regulation applied for the period 1985-1995 and effectively introduced a system of selective and exclusive distribution. Selectivity means that the manufacturer can choose his/her dealers and restrain them from reselling to anyone but end-users or approved sellers. Exclusiveness refers to the right of being the single seller in a designated territory, implying restrictions to engage in active sales promotion outside the territory (or country).[9]

The most significant property of the distribution system in preventing cross-border trade has been its selectivity. Regulation 123/85 explicitly specified that there could not be a refusal to sell to end-users, and that guarantees should remain valid, independent of the country of purchase.[10] So in theory, consumer rights were protected; in practice, however, life remained

much less significant.

[7]For example, the general importer of General Motors in Belgium was convicted in 1975 for demanding excessive fees with the evident intention to discourage parallel imports. BEUC (1982) reports that one importer even charged the difference between the two countries' local prices as a fee for issuing the type-approval certificate.

[8]The regulation was explicitly motivated on the grounds that cars are durable goods, and need as such high quality after-sales-service through an official distribution network.

[9]The Monopolies and Mergers Commission Report (1992) describes the distinction and subtleties of the selective and exclusive distribution system in greater detail in §§ 6.10–6.12 of their report.

[10]The duty to sell to consumers was based on case law before the regulation, the BMW Belgian cases (32/78 and 36-82/78) and the Ford cases (25/84 and 16/84). Note also that surcharges to foreign consumers were

complicated. An anonymous dealer survey by BEUC (1986) revealed a refusal to sell to foreign consumers in 20% of the cases; excessive delivery lags for right hand drive cars for the U.K.; and lower discounts to foreigners. These problems need to be added to the high transportation and information costs for unexperienced consumers seeking to purchase abroad. Furthermore, Regulation 123/85 formally erected obstacles against independent commercial importers who attempted to purchase cars in bulk. These were only allowed to act as intermediaries, with a written purchase authorization from their customers. This made it much more difficult to carry several cars in stock: one could easily be suspected of being a commercial importer once several cars had been purchased on the same name. Manufacturers sometimes even attempted to deny the independent wholesalers their (limited) right of acting as intermediaries, as evidenced by the Peugeot case in 1991. A Communication by the European Commission later relaxed the restrictions against the activities of independent commercial importers. It allowed professional authorized agents to engage in parallel imports subject to the quantitative restriction that no more than 10% of a dealer's sales could go to a single parallel importer.[11] The communication nicely illustrates how manufacturers have indeed attempted to raise consumer costs of purchasing a car abroad.

The 1985 Regulation also stated that the European Commission could withdraw the benefits of the Regulation in several instances, in particular "where, over a considerable time period, prices or conditions are applied which differ substantially between Member States and where differences are chiefly due to the obligations exempted by this regulation." In such circumstances, independent commercial importers would be allowed to purchase cars in bulk in one country and resell them in another. The maximally allowed international price differences were included in an original draft Regulation, but removed in the final version. They appeared, in weaker form, in a Communication notice accompanying the regulation.[12] It stated that price differences between two member states (excluding the high tax countries Danmark and Greece) should not exceed 12% during a period of 6 months, and 18% at any point in time. Despite the careful monitoring of price differences at a large scale, first by BEUC, and since 1992 at an official level by the European Commission, the benefits from the selective distribution system have never been withdrawn upon observing excessive price differences. As noted several times by BEUC, this is not surprising given the subjective qualification that the price differences should be shown to be chiefly due to the exemptions of the Regulation.

allowed in countries with a special (high) tax regime, i.e., in Danmark and Greece.

[11] Communication in Official Journal of the European Communities, O.J. nr. C329, 18 Dec. 1991, p 20.

[12] Communication Notice 85/C17/03.

Regulation 123/85 was renewed for another 7 years in 1995. Distribution remains selective, although the explicit condition has been added that manufacturers should not restrict consumers, or intermediaries acting on their behalf, to purchase from any dealer. Exclusiveness has been relaxed, in that dealers can now advertize outside their territory and can carry competing brands. Despite these additional conditions, there can be little doubt that manufacturers and official importers continue their practice of impeding sales to foreign consumers and intermediaries. This is evident from the recent 1998 Volkswagen case. Volkswagen has been accused and convicted for putting pressure on Italian dealers not to sell to German and Italian customers. Proof has been found that these practices had been going on for ten years. They involved threats to 50 dealers to withdraw their licenses, with 12 licenses effectively withdrawn. The conviction included a 102 million ECU fine (about 10 percent of Volkswagen's annual profits), the largest fine ever issued by the European Commission to a single firm, and the removal of Volkswagen's rights as set out in the Regulation. Similar investigations are under way against Mercedes and Opel.

A third obstacle to trade between countries of the European Community has been caused by the system of national registration. In combination with article 115 of the treaty of Rome, which enables member states to take protective measures against indirect imports from other member states, the system of national registration has had the effect of limiting trade of foreign, mainly Japanese models. Quantitative restrictions on imports from third countries, in particular Japan, have long existed in various European countries (France, Italy, Portugal, Spain and the U.K.). These restrictions take the form of import quotas or voluntary export restraints. The problem is, of course, that parallel imports from other European countries can undo the national restrictions. The requirement of national registration resolves this problem, since it can control cross-border trade of Japanese cars. In Italy, for example, there existed a tight quota of 3300 cars that could be directly imported from Japan. The total number of Japanese cars that could be officially registered in Italy, including cars from other European countries, was limited to 23000 (slightly more than one percent of the Italian market). When the national quotas were replaced in 1993 by a common import quota for the European Union as a whole, the requirement of national registration continued to maintain unofficial national quotas under various pretexts. For example, the agreement between the European Union and Japan contained "monitoring" and "projections of sales" in the countries in which quotas had previously existed (see Mason, 1994, for circumstantial evidence on this).

The best evidence for the obstacles to cross-border trade within the European Community is perhaps given by the magnitude of parallel imports, the goods imported by unauthorized resellers. Table 1 summarizes the evidence collected from various BEUC surveys. It reveals that parallel imports have been quite low in all Europeans countries of our study. They generally do not constitute more than three percent of the total market, and in many countries and years less than one percent. These small numbers are even more remarkable, given the very large cross-country price differences as plotted in the introduction.

Other strong evidence on trade restrictions within the European Community is given by the Japanese market shares. These differ drastically across countries. In principle, this could be due to differences in local tastes. The close correspondence to the allocated national quotas, however, suggests that countries have been very successful in preventing intra-European trade of Japanese models; in countries with a quota or voluntary export restraint, the actual Japanese market share only slightly exceeds the assigned quota.

Table 1 also presents the market shares of "domestic" firms, i.e., the market shares of the models that are produced domestically. In France, P.S.A. (Citroën and Peugeot) and Renault are the two "national champions". In Italy, Fiat has become the single domestic producer after it acquired Lancia in the seventies and Alfa Romeo in 1986. Germany has Volkswagen (including Audi), BMW and Mercedes; in addition, there is production by U.S. transplants of General Motors (owning Opel) and Ford. In the United Kingdom, Austin Rover (recently acquired by BMW) combines various old brand names; there is also production by U.S. transplants of General Motors (owning Vauxhall) and Ford, and some Japanese firms (Honda and Nissan) that were attracted in the late eighties. In Belgium, there is local production by Ford (the Taunus/Sierra/Mondeo line). Table 1 demonstrates that domestic firms have high and stable market shares in Germany and France, and to a lower degree also in Italy and the United Kingdom. In all countries (except Belgium), the market share of domestic firms is more than twice the average over the five countries. Especially in Italy and the United Kingdom there is a very strong presence of domestic firms relative to the European average. These national consumption patterns may stem from differences in local tastes (possibly including differences in the sizes of dealer networks), or be the result of trade barriers within Europe.

3. A First Look at the Data

3.1 The Data Set

The data set we have constructed to analyze price dispersion has essentially three dimensions: (1) Products: In each year there are approximately 150 models in our sample. For each model we have information on sales, list price, and physical characteristics of the base specification. These include engine attributes (horsepower, displacement), dimensions (weight, length, width, height) and performance variables (fuel consumption at 3 levels of speed, acceleration time, maximum speed); they often vary across markets. All data are from publicly available sources.[13] (2) Time: Our sample extends from 1980-1993. (3) Markets: There are five markets in our sample: Belgium, France, Germany, Italy and the United Kingdom. These countries represent a large spectrum for several reasons: the size of the market varies from ca. 400,000 units per year in Belgium to almost 3 million cars in Germany; the degree of import penetration ranges from ca. 30% in France and Germany to almost 100% in Belgium; the Japanese penetration varies from ca. 1% in Italy to 20% in Belgium; tax rates vary from 14% in Germany to 33% in France in the early years, and 25% later; and the C1-concentration index ranges from 53% in Italy to 16% in Belgium.

In addition, our database contains information on the production location of each model (source: Pemberton Associates); brand ownership and class; average and maximum dealer discounts for selected years (source: BEUC reports, and unpublished interviews by CECRA, the European Committee for Motor Trades and Repairs in Brussels); exchange rates (source: IFS statistics); tax rates (source: the retail catalogues mentioned in the last footnote); and income distribution in each market (source: Atkinson, 1997). Some summary statistics are provided in Table 1.

3.2 Quality Adjusted Price Differences

To investigate whether the price dispersion documented in Figure 1 is random or systematic, we start by constructing hedonic price indices for each market and each year in our sample. These indices control for quality differences as measured by the observed physical characteristics of a car. The basic hedonic price equation we estimate is:

$$ln(p_{jmt}^{ECU}) = w_{jmt}\gamma + \delta\, tax_{mt} + \theta_c + \theta_f + \theta_{st} + \theta_{mt} + \epsilon_{jmt} \qquad (1)$$

[13] Price and characteristics data are available from retail catalogues, i.e., De Autogids, Auto Moto Revue, Journal de l'Automobile, Katalog der Automobil Revue, Adac Auto Special, What Car?, and Quattroruote. Sales data are the number of national registrations, and come from Nieuwe tot het Autoverkeer Toegelaten Voertuigen, l' Argus de l'Automobile et des Locomotions, Automobil Revue, MVRIS, Notziario Statistica, Tatsachen und Zahlen aus der Kraftsverkehrswirtschaft, and World Motor Vehicle Data. These publications are available at the libraries of FEBIAC (Brussels) and CCFA (Paris).

The subscripts j, m and t refer to product j, market m and year t respectively. The vector w_{jmt} consists of physical car characteristics (horsepower, size, etc.) that may vary across markets, while θ_c and θ_f are market segment and firm dummies respectively. Price differences due to cross-country tax differences are captured in the regression through *tax* (the log of the value added tax). In addition, we include a set of source country/time dummies (θ_{st}) to control for differences that may be due to a common cost shock facing firms located in a particular country of origin (e.g. an increase in wages facing all Japanese firms). Given this specification, the destination/time effects θ_{mt} capture the residual cross-country price differences that cannot be explained by differences in quality or taxation across markets. All differences are measured in percentage terms relative to Belgium. We experimented with various other specifications of equation (1) (e.g., including dummies for domestic brands, excluding tax rates, including interactions of Japanese product and market dummies to capture the effects of the quota constraints) and the destination/time effects θ_{mt} were quite robust.

The results from estimation of equation (1) are summarized in Table 2. All parameters have intuitive signs and are precisely estimated. Given the large number of included destination/time effects we do not report them individually; however, at the bottom of the table, we report the 95% confidence interval for the destination effects in 5 distinct years: 1980, 1985, 1990, 1992 and 1993. The point estimates of the destination/time effects are plotted in Figure 2.

The first pattern that emerges from Figure 2 (and Table 2) is that there are large, persistent and statistically significant cross-country price differences, even after we adjust for quality and taxation differences. During almost the entire sample period, France, Germany, Italy and the U.K. are more expensive than Belgium; the only exception to this pattern is 1993, when the destination effects for the U.K. and Italy become statistically insignificant. The U.K is associated with the highest prices throughout the sample period, followed by Italy. Although the point estimates for the U.K. are almost always above the ones for Italy, the difference between the two countries is not statistically significant after 1992. Prices in France are relatively high early in the sample period (up to 1986), but become statistically indistinguishable from the ones in Germany after 1987. German prices are 3%-5% higher than the ones in Belgium during the entire period. If we were to characterize price dispersion during this period in a few words, we would group the five countries in our sample into three categories: Belgium (the cheapest), France and Germany, and Italy and the U.K. (the most expensive).

The second pattern that emerges from Figure 2 is that the hedonic price indices are extremely volatile. Even though the ranking of the countries remains fairly stable, year to year changes in the destination effects are fairly large. The perhaps most dramatic changes are in 1993, when both the U.K. and Italy (the relatively more expensive countries in the sample) drop below Germany and France.

Given this volatility and the 1993 effects in particular, it is compelling to relate the movements in the price differences to exchange rates. Figure 3 plots the exchange rates of France, Germany, Italy and the U.K. vis a vis Belgium. It appears that the movements in the hedonic price indices plotted in Figure 2 closely track the exchange rate movements in Figure 3. This is particularly evident in 1986 and 1987 when the English pound depreciates and the U.K. hedonic price indices suddenly drop. Similarly in 1993 the decrease in the hedonic price indices for the U.K. and Italy coincides with the depreciation of these countries' currency. The high correlation between exchange rate and price index movements is even more pronounced in Figure 4 that plots the annual changes in price differences and exchange rates; the year-to-year changes in the two variables are highly correlated. This is indicative of the short run effects of exchange rates on price differentials; because local currency prices do not fully respond to a currency appreciation (depreciation) in the short run, prices denominated in ECUs will naturally be correlated with exchange rates. A graphical illustration of the same relationship is provided in Figure 5 that plots the destination effects after exchange rate volatility has been controlled for. To produce this figure, we reestimated equation (1) including the log of the exchange rate of each country vis a vis Belgium as a regressor. As evident from the results in column 2 of Table 2, the inclusion of the exchange rate primarily affects the time/destination effects (the other coefficients hardly change when exchange rates are included). These effects, have no clean interpretation as quality adjusted price differences any more. But, as the plot in Figure 5 illustrates, a large fraction of the volatility in θ_{mt} disappears, once exchange rates are controlled for.

Given that exchange rates seem to play an important role in explaining the volatility of auto prices, we now turn to a more rigorous investigation of their effects.

3.3 The Role of Exchange Rates

The hedonic regression reported in column 2 of Table 2 controls only for changes in the exchange rate of each destination market relative to Belgium. In each market, however, there are several producers of different nationalities, each of which faces a distinct exchange rate vis a vis the destination market. To take this into account we estimate an equation of the following general form:

$$ln(p_{jmt}^{exp}) = w_{jmt}\gamma + \delta\, tax_{mt} + \theta_c + \theta_f + \theta_{st} + \theta_{sm} + \beta_{sm}\, ln(e_{smt}) + \epsilon_{jmt} \qquad (2)$$

This specification is similar to the hedonic pricing equation estimated before. There are three main differences: First, the left hand side variable is now expressed in exporter currency units; second, the destination market/time effects are replaced by the log of the exchange rate of each source country vis a vis the destination market (i.e., units of source currency per unit of destination currency); third, we now introduce source country/destination market fixed effects (θ_{sm}). The coefficient β_{sm} is called the pricing-to-market (or exchange rate pass-through) coefficient.[14] If β_{sm} is equal to 0, local prices fully respond to exchange rate changes; prices remain unchanged in exporter currency units, and pass-through is characterized as complete. If, at the other extreme, local prices are completely unresponsive to exchange rate changes, β_{sm} is equal to 1. In this case, exporters fully adjust their prices in order to absorb the exchange rate change. Values of β_{sm} between 0 and 1 indicate incomplete exchange rate pass-through. Given that everything is specified in levels (and not first differences), the coefficient β_{sm} can be thought of as capturing the long term response of prices to exchange rate fluctuations. The specification in (2) is very similar to the equations estimated in the pricing-to-market literature, most notably by Knetter (1989, 1993); it has, under certain more or less plausible conditions, a semi-structural interpretation.

In a competitive, integrated world all export prices would equal the common across destinations marginal cost. In the regression model, the source/time effects would measure the common price in each period, which would be an exact measure of the marginal cost. In this case, there would be no residual variation in prices, and both the market specific effects θ_{sm} and the coefficient β_{sm} would be zero.[15]Imperfectly competitive, integrated markets have simi-

[14]The terms pricing-to-market and exchange rate pass-through are sometimes used interchangeably in the literature. We use the term "pricing-to-market" here to emphasize that our pass-through regressions are carried out in a multidestination framework. As discussed in Goldberg and Knetter (1997), this framework offers the advantage of allowing us to distinguish common across markets movements in the marginal cost from exchange rate induced movements in the markup. See also the discussion below.

[15]This assumes that we have sufficiently controlled for cross-country cost differences that remain constant in time. This assumption may be problematic in the case of Germany, where the early introduction of catalytic converters may have increased the cost of all car models sold in Germany in the early years of our sample, and also the U.K., where the right hand side steering wheel may affect the costs of all models sold there by the same proportion. Nevertheless, one would expect the θ_{sm}'s resulting from such cost differences to be relatively small.

lar implications for the coefficients. The markup of price over marginal cost need not be zero in this case; but given that integration implies price equalization across buyers, all the market specific effects would be zero.

Now consider the case of imperfect competition with market segmentation. There are two possible subcases to consider. Suppose first that firms in each destination market face constant elasticities of demand. In this case, the price charged in each market would be a fixed markup over marginal cost. In the regression model, the source country/time effects would give an index of the marginal cost of each exporter, and the destination specific components θ_{sm} would measure differences in the (fixed) markups relative to the base country (Belgium in our case). The coefficient β_{sm} would again be zero. The second possibility is imperfect competition with non-constant elasticities of demand. Both θ_{sm} and β_{sm} would be significantly different from zero in this case; not only would markups vary across markets, they would also be correlated with exchange rate variations. Hence, there are three inferences one can draw from statistically significant values of θ_{sm} and β_{sm}: existence of market segmentation, price discrimination, and non-constant elasticities of demand. Implicit in the above inferences is the assumption that there is no local component in the marginal costs of cars sold in different destinations; hence, the marginal cost of a car expressed in exporter currency is unaffected by exchange rate fluctuations.[16] In the pricing-to-market framework there is no simple way to account for local production or selling costs; their implications are investigated more thoroughly later in the paper within a more structural framework.

We start by estimating a version of (2) in which the same pricing-to-market coefficient is imposed for all source countries and all destinations ($\beta_{sm} = \beta$).[17] All source country/market effects are statistically significant; the average pricing-to-market coefficient (β) is estimated at 0.46 (standard error 0.02). In the absence of a local component in marginal costs, these results imply that the price dispersion documented in the five European markets in our sample is due to price discrimination, that is highly correlated with exchange rate variation. In particular, the point estimate of 0.46 for the pricing-to-market coefficient implies that, on average, auto producers absorb 46% of the exchange rate fluctuations through markup adjustment, while

[16]This is a reasonable assumption in Knetter's work that employs f.o.b prices. It is more questionable in our application, since the prices we use are retail prices in each market.

[17]Given that all following regressions look similar to the basic hedonic regression of Table 2, we do not report the results in full detail, but only concentrate on the relevant coefficients. In particular, all regressions have very high R-squares (above 0.97) and Durbin-Watson statistics around 1.8; the coefficient estimates for the car attributes, the class and the firm dummies are roughly the same as in Table 2.

local prices remain relatively stable.

Next, equation (2) is estimated allowing the pricing-to-market coefficients to vary across source countries and destinations. Given that there are 10 source countries and 5 destination markets in our sample, this implies approximately 50 β_{sm}'s to be estimated (estimation is of course subject to the usual identification constraints). The results from this regression (not reported here) indicate substantial variation of the coefficient estimates across destinations and source countries. Rather than listing all β_{sm} estimates below, we report results from a more parsimonious specification in which β_{sm} was decomposed additively into a destination market and a source country component ($\beta_{sm} = \beta_s + \beta_m$). The results are listed in Table 3.

The first row reports the coefficient estimates for each source country (standard errors in parenthesis). Three out of the eleven coefficients are not statistically significant, while the point estimates are relatively low. These correspond to Belgium, Korea and the Netherlands. The observations corresponding to these countries are two few (imports from these three countries represent an almost negligible fraction of total sales in Europe) to allow a precise estimation of the coefficients. Among the other seven source countries, Spain, Sweden and the U.K. exhibit the highest coefficients, while Germany and Japan the lowest. Overall there seems to be substantial variation in the coefficient estimates across source countries. This variation is contrasted with the average (across the five markets and all sample years) market shares of each source country in row 2 of the table. It appears that exchange rate pass-through is inversely related to market shares; countries with a relatively strong presence in the destination markets (e.g., Germany) are more likely to adjust the local prices in response to exchange rates, while countries with very small shares (such as Spain and Sweden) absorb the exchange rate changes by adjusting their markups, leaving local prices relatively stable.

Given this pattern in the pricing-to-market coefficients we reestimated equation (2), including the market share of each model and its square on the right hand side. The results confirm the pattern revealed in Table 3. The market share coefficient is negative and statistically significant (-0.25 (0.08)), while the coefficient on the square is positive (7.71 (1.49)). Even though we do not want to make too much out of this preliminary descriptive analysis,[18] it seems fair to say that the data suggest that pass-through increases with market share, but at a decreasing rate. As a further check on this correlation, we also estimated pricing-to-market equations

[18]The above regression very likely suffers from simultaneity bias, as it is essentially a regression of prices on market shares. Note, however, that our only goal here is a descriptive one, that is to establish the main correlations in the data. We do not attempt any more rigorous interpretation at this stage.

separately for each model and then plotted the estimated pricing-to-market coefficients against the market share of the model. This graph produced roughly a U-shaped curve.

Row 3 of Table 3 reports the market specific components of the pricing-to-market coefficients. The only coefficient that is statistically significant is the one for the U.K.; the associated point estimate is also quite large. This is consistent with the pattern revealed in Figure 2; the U.K. is the most expensive destination for almost the entire sample period, and it is also the one with the highest degree of local price stability.

Overall, the pricing-to-market regressions suggest that local price stability is an important feature of European auto markets during periods of exchange rate volatility. Note that both the frequency of our data (annual) and the nature of the regressions suggest that this is not a stability that pertains only to the short run, due to lagged adjustment; it persists in the long run, and generates significant price differences across countries. The strong correlation between market shares and exchange rate pass-through suggests that local price stability may be related to the competitive conditions in each market.

3.4 Convergence?

Even though the raw data plotted in Figure 1 show no indication of convergence over time, the hedonic price indices of Figure 2 seem to come closer together in the late 1980's and early 1990's. To investigate whether the European intergration process has reduced the quality adjusted price differentials we estimate the following "convergence" equation:

$$\Delta hpi_{mt} = const + \lambda\, hpi_{m,t-1} + \mu\, \Delta log(exr_{mt}) + u_{mt} \tag{3}$$

The dependent variable is the first difference ($\Delta hpi_{mt} = hpi_{mt} - hpi_{m,t-1}$) of the hedonic price indices obtained from estimation of equation (1). It is regressed on a constant, the first lag of the hedonic price index for each market, and the first difference of the log of the exchange rate of each market vis a vis the ECU. To the extent that there is any convergence over our sample period, one would expect the coefficient λ to be significantly negative. The first difference in the exchange rate is included to capture the role of exchange rates in the relative movements of the hedonic price differences. The results from estimation of equation (3) for the full sample, as well as various subsamples, are displayed in Table 4.

The full sample coefficients suggest the presence of convergence over our sample period.

Note, however, that the convergence coefficient becomes significant only when exchange rates are included. Moreover, including the exchange rates in the estimation increases the R-square from 0.04 to 0.86. This pattern is also evident in the results for the subsamples. It seems that exchange rates play an important role.

By looking at the results for various subsamples we get a more concrete idea as to what drives convergence over the sample period. There are two patterns to note here. First, eliminating the late years in the sample (1990-93) produces convergence coefficients that are not significantly different from zero. Second, when the early years of the sample (1980-86) are left out, the convergence coefficient is significantly negative when the equation is estimated without exchange rates, but becomes insignificant as soon as exchange rates are included. This is particularly evident in the last two columns of the table that report results for the 1987-1991 period. It seems, that to the extent that there is any convergence during this period, it is entirely due to exchange rates moving in the right direction;[19]once the exchange rate effects are controlled for, the convergence coefficients become small, and not significantly different from zero. Overall, there are three conclusions one can draw from the results; first, there seems to be some convergence over the sample period; second, this convergence is due, to a large extent, to exchange rate movements; third, to the extent that convergence represents true progress towards an integrated Europe, it seems that the most significant developments took place either in the early and mid-1980's (1985-87 in particular), or around 1991-92.

3.5 Summary of Findings

The preliminary data analysis points in summary to two main features of price dispersion in Europe: (1) Existence of substantial and persistent differences in quality adjusted prices across countries, and (2) Substantial year-to-year volatility. A large fraction of this volatility (but not all of it) is accounted for by exchange rate fluctuations. An analysis of the effects of exchange rates on prices within the pricing-to-market framework indicates that local prices remain relatively stable during periods of exchange rate realignments. This local price stability could in turn be generated by local production and selling costs and/or third degree price discrimination. Exchange rates seem to also be the main factor driving any price convergence suggested by our regression results.

[19]This is particularly evident in 1992-93, when the depreciation of the British pound and the Italian lira made the U.K. and Italy relatively "cheap". This was, however, a short-lived phenomenon. By 1998, when the pound had regained in strength, the U.K. had become the most expensive destination again.

The remainder of our analysis will be devoted to explaining the facts revealed in the descriptive analysis, and quantifying the contributions of the various components responsible for price dispersion. The quality adjusted price differences in any given year can in principle be accounted for by cross-country differences in marginal costs, differences in the restrictiveness of import barriers, varying degrees of collusion, and differences in the price elasticities of demand. Accordingly, we build an empirical model in the next section that allows each of these factors to have a potential effect on prices. Explanations for the time pattern of the price differentials, the high degree of local price stability in particular, are however less obvious.

In principle, one could think of three factors being responsible for the local price stability observed in our data. The first one is the presence of a large local component in marginal costs; if, for example, each firm produced the products it sold in each market locally, it would be no surprise if local currency prices did not react to exchange rate movements. In our empirical model, we account for the potential existence of local costs in total production. A-priori, however, it seems unlikely that local costs could entirely explain the local price stability documented in the previous section. The production location data suggest that almost all models are produced in a single location, and not in the individual markets where they are sold; hence, in our multi-destination framework, exchange rate movements between any two destinations will inevitably change the relative costs of selling in these two markets. The second potential explanation builds on dynamics, either on the demand or the supply side, that can generate adjustment lags in the response of local prices to exchange rates; but the persistence of price differentials documented in our data makes this explanation rather unlikely. It is, for example, plausible to presume that an appreciation of the pound would make U.K. prices appear high in the short run; producers would find it undesirable to adjust their local prices immediately, especially if the appreciation was considered to be temporary.[20]But adjustment lags cannot explain why the U.K. is systematically more expensive in ten out of the fourteen years of our sample. The final explanation is that producers simply find it profitable to keep their prices stable when faced with cost shocks. This requires a convex demand schedule. When prices start going up, the price elasticity of demand facing the firm increases; when they go down, the price elasticity falls. The unsettling aspect of this explanation is of course, that all one needs for it to come through is assume the "right" functional form. Rather than taking this path, we estimate a flexible demand system that seems appropriate for the auto market, and then investigate its implications for local price stability.

[20]Note, however, that most countries in our sample are members of the EMU; this makes it more likely that producers would consider currency realignments as permanent.

4. The Empirical Model

The following subsections describe the three components of the empirical model: demand, cost and oligopoly pricing.

4.1 Demand

The Discrete Choice Framework: The demand side of the market is modelled in a discrete choice framework. This approach offers two advantages. First, it solves the dimensionality problem associated with estimation of product differentiation models involving a large number of products; in the automobile market this problem is acute, as ca. 100 distinct models are sold in each country, implying that ca. 10,000 cross-price elasticities have to be estimated. Second, the utility maximization framework is ideal for conducting welfare analysis, which is one of the objectives of our project.

Because of our interest in the demand elasticities, it is particularly important to adopt a reasonable and flexible specification for the utility function. Ideally, our estimation approach would exploit data at the individual consumer level; such data would allow us to introduce consumer heterogeneity and its interactions with product characteristics in a very flexible manner. Unfortunately, such micro data are not available for any European country. We therefore employ product level data, and utilize recent insights from the Industrial Organization literature (e.g., Berry (1994), Berry et al (1995), Goldberg (1995), Verboven (1996), Bresnahan et al (1997), Nevo (1997)) to inform the specification. Since we do have data on the income distribution in each country, we adopt a specification that allows us to at least utilize this information.

Consider consumer i, in market m at time t. The consumer faces $J_{mt} + 1$ alternatives: J car models offered at time t in market m, plus the option not to buy a new car ($j = 0$). The indirect utility the consumer maximizes is assumed to take the form:

$$U_{ijmt} = \delta_{jmt} + \alpha_m ln(y_{imt} - p_{jmt}) + \epsilon_{ijmt} \tag{4}$$

The first term, δ_{jmt}, captures the mean evaluation for good j, common to all consumers. It can be written as:

$$\delta_{jmt} = x_{jmt}\beta_m + \xi_{jmt} \tag{5}$$

The vector x_{jmt} consists of observable vehicle characteristics (size, horsepower, cylinders, options, etc.), while ξ_{jm} captures unobserved quality. The second and the third term in (4) capture individual-specific evaluations for good j through two channels: the income term y_i, and the additive error term ϵ. The subscript m in the parameters β and α imply that we allow preferences to vary across markets. Alternatively, one could impose the same parameters, and hence the same preference structure, across countries. Since we want to impose the minimum amount of restrictions at this stage, we adopt the specification in (4), and examine later whether the equality restrictions are supported by the data.

Equation (4) can also be written in shorter form as:

$$U_{ijmt} = V_{ijmt} + \epsilon_{ijmt} \tag{6}$$

The term V_{ijmt} captures all terms except the random term in U_{ijmt}. This notation is useful in presenting the demand model in the remainder of this subsection. For notational convenience, we drop in the following the explicit reference to subscripts m and t; these do, however, remain implicit in the specifications we introduce.

Distributional Assumptions on the Error Term: It is well known that the shape of the demand function depends crucially on the distribution of the random shocks ϵ. Significant guidance in the search for appropriate distributional assumptions is provided by McFadden (1978), who in Theorem 1 states the conditions under which the specified distribution is consistent with random utility maximization. In particular, let $F(\epsilon_{i0}, ..., \epsilon_{iJ})$ denote the $J+1$ dimensional CDF of ϵ. According to Theorem 1:

If $G(y_0, ..., y_J)$ is a nonnegative, homogeneous-of-degree-one function satisfying certain restrictions, then

$$F(\epsilon_{i0}, ..., \epsilon_{iJ}) = exp(-G(e^{-\epsilon_{i0}}, ..., e^{-\epsilon_{iJ}}))$$

is the multivariate extreme value distribution, and

$$P_{ij} = \frac{e^{V_{ij}} G_j(e^{V_{i0}}, ..., e^{V_{iJ}})}{G(e^{V_{i0}}, ..., e^{V_{iJ}})} \tag{7}$$

defines the probability of choosing alternative j, where G_j is the partial derivative of G with respect to $e^{V_{ij}}$.

The above theorem offers considerable flexibility in the specification of the demand system, as it demonstrates that a wide variety of substitution patterns are consistent with random utility maximization. Depending on the choice of the function G, one can derive a variety of models that have been popular in the empirical literature: the logit, the one-level-nested logit, the multi-level-nested logit, or non-nested models, such as the ones considered in Small (1987) and Bresnahan et al (1997). Each of these models has different implications for the cross-product elasticities; hence, one can think of equation (7) as providing a general framework that allows us to parameterize the substitution patterns across products.

Equation (7) is our point of departure in the derivation of the demand system. The question is, of course, how to choose the appropriate G function. Given the voluminous economic and marketing research on the auto market, it is reasonable to narrow the search for appropriate functional forms by focusing on specifications that utilize priors formed by this earlier literature. The marketing research suggests that the auto market is differentiated along two dimensions: market segment or "class", and country of origin (domestic vs. foreign in particular).[21] This suggests parameterizing the distribution of the error term using at least two parameters: the first one, ρ_c, captures the pattern of dependency across products in the same class; the second one, ρ_f, parameterizes the substitutability across products of either domestic or foreign origin. We consider two alternative G-function specifications that seem, a-priori, appropriate for the auto market. The first one is given by:

$$G(e^{V_i}) = e^{V_{i0}} + \sum_{k=1}^{K} \left\{ \left[\left(\sum_{j \in D, C_k} e^{\frac{V_{ij}}{\rho_f}} \right)^{\frac{\rho_f}{\rho_c}} + \left(\sum_{j \in F, C_k} e^{\frac{V_{ij}}{\rho_f}} \right)^{\frac{\rho_f}{\rho_c}} \right]^{\rho_c} \right\} \quad (8)$$

where C_k denotes class k (subcompact, compact, etc.), F stands for foreign products, and D stands for domestic products. This specification gives rise to the familiar bi-level nested logit; the two levels correspond to the two dimensions along which cars are differentiated, namely class, and domestic vs. foreign. To be consistent with random utility maximization (i.e. consistent with the conditions in McFadden's theorem), both ρ_c and ρ_f have to lie in the unit interval; in addition, ρ_f has to be less than, or equal to ρ_c. The interpretation of the distributional parameters is as follows: As either ρ decreases, the dependency across products in the corresponding cluster becomes stronger; as either ρ goes to 0, products in the corresponding

[21]The best confirmation of the importance of these two dimensions, is the way car statistics are reported in auto journals; these are always organized in terms of class and country of origin.

cluster become perfect substitutes. Conversely, as ρ goes to 1, the dependency becomes weaker; in the limit case of $\rho = 1$, the error terms become independent within the cluster, and the model reduces to a one-level nested logit. Similarly, if $\rho_c = \rho_f$, the model reduces to a single level nested logit.

The second specification we consider is:

$$\begin{aligned} G(e^{V_i}) = e^{V_{i0}} &+ \alpha_c \left[\left(\sum_{j \in C_1} e^{\frac{V_{ij}}{\rho_c}} \right)^{\rho_c} + \ldots + \left(\sum_{j \in C_k} e^{\frac{V_{ij}}{\rho_c}} \right)^{\rho_c} \right] \\ &+ \alpha_f \left[\left(\sum_{j \in D} e^{\frac{V_{ij}}{\rho_f}} \right)^{\rho_f} + \left(\sum_{j \in F} e^{\frac{V_{ij}}{\rho_f}} \right)^{\rho_f} \right] \end{aligned}$$

$$\alpha_c = \frac{1 - \rho_c}{2 - \rho_c - \rho_f} \;,\; \alpha_f = \frac{1 - \rho_f}{2 - \rho_c - \rho_f} \tag{9}$$

This gives rise to the generalized extreme value model considered in Bresnahan et al (1997). The G function is here a weighted average of two one-level nested logit models. The parameters ρ_c and ρ_f must again lie in the unit interval. As either ρ goes to 1, the associated weight (α_c or α_f) goes to zero, implying that the corresponding dimension of product differentiation is irrelevant.

In both cases, the deterministic part of the utility corresponding to the outside good is normalized to zero: $V_0 = 1$. Note that both specifications involve the same number of distributional parameters (2); hence, one cannot motivate one parameterization as being richer than the other. Each specification has, however, different implications about the shape of the demand function, the substitution patterns in particular.

Implications for the Substitution Patterns and Comparison to Alternative Models: Consider first the bi-level nested logit model with "class" on the top, and "foreign vs. domestic" at the bottom. This model implies that the cross price elasticities between any two products decline as we move from the bottom to the top of the nested structure. More specifically:

$$\eta_{co,co} \geq \eta_{co,co'} \geq \eta_{co,c'o} = \eta_{co,c'o'}$$

where $\eta_{co,c'o'}$ stands for the cross price elasticity between two products, one belonging to class c and origin o, and one belonging to class c' and origin o'. Note that this structure is not as restrictive as it may at first seem. The cross price elasticities between two products belonging to different nests can in principle be as large as the cross price elasticities between two products belonging to the same nest, as the above relationship indicates. More importantly, depending on the estimated values of ρ_c and ρ_f, one may reject the nested logit structure in favor of alternative specifications, e.g. a reverse ordering of the nests (if one of (or both) ρ's is outside of the unit interval), a one level nested logit (if, for example, one of the ρ's is equal to 1, or $\rho_c = \rho_f$, or even a simple multinomial logit. Tests of the "independence of irrelevant alternatives" (IIA) property within each cluster, may further serve as a specification check, potentially indicating that a further break-down of the nests is called for. In short, while the nested logit imposes some structure on the cross price elasticities, the imposed restrictions are testable.

Nevertheless, it is unsettling that within the nested logit model described above a price change in a (co) product has the same effect on demand in the partially matching category of $(c^{'}o)$ as it has on the completely unmatching category $(c^{'}o^{'})$. As discussed in Bresnahan et al (1997), the second specification we consider in the estimation (equation (9)) relaxes this restriction. The substitution patterns implicit in (9) are summarized by:[22]

$$\eta_{co,co} \geq (\eta_{co,co'}, \eta_{co,c'o}) \geq \eta_{co,c'o'}$$

The two dimensions of product differentiation are treated here in a completely symmetric way. Our main interest in estimating a model based on (9) stems from the fact that we do not want to impose the restriction that the substitutability of two cars of the same class but different origin is necessarily greater than the substitutability of two cars belonging to different classes.

Between the specifications described by (8) and (9) we have covered, we believe, a wide range of possible substitution patterns. While further generalizations of the demand structure are possible (see, for example, Berry et al (1995)), the specified model offers a reasonable compromise between functional form flexibility and computational tractability.[23]The latter is high in our priority list, as it allows us to better exploit the richness of our data set by experimenting with different specifications.

The Aggregate Market Share Function: Because of the unavailability of consumer level

[22]See Bresnahan et al (1997) for a more detailed discussion

[23]Estimating a random coefficients model would, for example, be extremely cumbersome in our case, given that we estimate the model for 5 distinct countries, and we are interested in conducting a series of policy simulations at the end. One can, however, think of the nested logit as a special case of the random coefficients model, one in which random coefficients are only estimated on dummy variables corresponding to each nest. As it turns out this special case works quite well in the auto market; the reason is that there is relatively little variation in observed characteristics across products in the same nest (they all have approximately the same size, cylinders, etc.), so that a nest dummy does a quite good job in capturing the variation in the data.

information, equation (7) has to be aggregated up to the product market share function before the model can be taken to the data. As mentioned above, our data set includes information on the income distribution in each country. We use this information to define 10 income classes. Let λ_i be the fraction of consumers belonging to income class i.[24] The market share of product j is then given by

$$s_j = \sum_{i=1}^{10} P_{ij}\,\lambda_i \tag{10}$$

and the market share of the outside good is

$$s_0 = \sum_{i=1}^{10} P_{i0}\,\lambda_i \tag{11}$$

where $\sum_{i=1}^{10} \lambda_i = 1$, and P_{ij} and P_{i0} are given by equations (7) and (8) (or (9)) above.

4.2 Marginal Cost

The marginal cost of each vehicle make is treated as unobservable, and modelled parametrically as a function of the car's physical characteristics, factor prices and total production quantity. Specifically, we adopt the following Cobb Douglas specification for marginal cost of product j in market m at time t:

$$\frac{\partial C_{jmt}}{\partial q_{jmt}} = \exp(z_{jmt}\gamma_s + \omega_s + \omega_f + \omega_m + \omega_t + \omega_{jmt}) W_{st}^{\delta} F_{st}^{1-\delta} Q_{jt}^{\zeta} \tag{12}$$

Marginal cost is expressed in the currency of the production location indexed by s.[25] It is homogeneous of degree one in wages W_{st} and other factor prices F_{st}. The quantity Q_{jt} refers to the total world sales of product j. By including it in our specification we allow for non-constant returns to scale: a positive (negative) coefficient indicates decreasing (increasing) returns to scale.

The vector z_{jmt} denotes the physical characteristics of product j. Note that this formulation allows model specifications to vary across destination markets, so that we can capture cross-country cost differences arising from differences in quality; similarly, it controls for changes in quality over time. The parameter vector γ can again be source country specific (as the notation in (12) implies), or constrained to be the same across production locations ($\gamma_s = \gamma$). We experiment with both specifications. The error term ω may be interpreted as capturing unobserved

[24]This λ_i is of course country specific in our application; we also allow it to be time-specific, but in practice the income distribution hardly changes over our sample period.

[25]Note that this may vary from the country of firm ownership; some Japanese models, for example, are produced in European countries.

characteristics influencing marginal cost. It contains fixed effects for firms and production locations (ω_f and ω_s respectively), which may arise from differences in efficiency across firms and locations. In addition, it contains a market effect (ω_m), which captures unmeasured factors that influence the marginal cost of all cars sold in a particular destination market. These may arise from different local regulations or other institutional factors. For example, the required use of catalytic converters in Germany would increase the marginal costs of all cars in this country; in the U.K., it is generally believed that cars are better equipped than in other European countries, because of the importance of the leasing market.

Implicit in the denomination of marginal costs in source country currency is the assumption that all production costs occur in the source country. This assumption may be inappropriate if some inputs have been purchased abroad, or a certain component of a product's costs (mainly distribution and selling costs) is local to the destination market. To assess the importance of such a local component we also consider a specification in which the log of the exchange rate of the source country vis a vis the destination market (i.e., units of destination currency per unit of source currency) is included on the right hand side of (12). If 100% of the production costs occur in the source country, the exchange rate coefficient should be zero; a significantly negative coefficient is indicative of the presence of a local component in production costs.

4.3 Oligopoly Pricing

The European automobile market is modelled as an oligopoly with multiproduct firms. In each market m at time t, firm f sells a subset F_{fmt} of the J_{mt} car models sold in this market/year. The sales of each car model in market m, $q_{jmt}(p_{mt})$, are given by the product of the market share of j and the number of potential consumers L_{mt}:

$$q_{jmt}(p_{mt}) = s_{jmt}(p_{mt})L_{mt}.$$

The determination of the market share was already discussed in the subsection on demand. Assuming prohibitive arbitrage costs to consumers, this share will be a function only of the price vector in market m at time t, p_{mt}, and not of the price vectors in other markets. As the evidence presented in section 2 demonstrates, the assumption of prohibitive arbitrage costs is not unreasonable. The number of potential consumers is assumed to be the number of households in each market.

The equilibrium concept is Nash. We start by considering the case of Bertrand competition.[26] The assumption of price setting is common, and consistent with industry wisdom. The framework we adopt is however flexible enough to also accommodate the case of collusion. Collusion may be present in the European markets because of the existence of quantitative import restrictions; as the trade literature has shown, these can often serve as collusive devices among producers.

The relevant price for the firm's profit maximization problem is the wholesale price p^w_{jmt}. It is assumed this is proportional to the observed list price according to:

$$p^w_{jmt} = p_{jmt}/[(1 + t_{jmt})(1 + \tau_{jmt})] \tag{13}$$

where t_{jmt} denotes value added taxes in market m, and τ_{jmt} refers to the dealer markup. This is treated as exogenous in our framework.[27] In France, Germany and the U.K. value added taxes are the same percentage for all cars. In Belgium and Italy, this percentage is model-specific: cars with a powerful engine have a higher value added tax.

Each firm maximizes its profits over the M markets at period t, as given by:

$$\Pi_{ft} = \sum_m \sum_{j \in F_{fmt}} e_{fmt} p^w_{jmt} q_{jmt}(p_{mt}) - \sum_{j \in F_{fmt}} e_{fst} C_{jt}(q_{j1t}(p_{1t}), ..., q_{jMt}(p_{Mt}))$$

The wholesale prices p^w_{jmt} are expressed in local destination currency. $C_{jt}(.)$ refers to the production cost of model j, expressed in the currency of the production location. The term e_{fmt} denotes the exchange rate (at time t) between the firm f's country of registration and the destination market (i.e. units of f's currency per unit of m's currency), while e_{fst} is the exchange rate between the firm's registration country and model j's production location. This formulation allows us to account for the diversified activities of multinational enterprises, and capture the effects of exchange rate changes on prices.

Cars imported from Japan face quota constraints in the European automobile market. In some countries (e.g. Italy), the constraint is expressed as an absolute upper limit on imports,

[26] Theoretical work in the area of discrete choice has provided a general proof of the existence of a pure strategy Nash equilibrium, assuming single product, price setting firms (see Caplin and Nalebuff (1991)). A general proof for the case of multiproduct firms is not available; Anderson and de Palma (1992) prove existence for a simplified symmetric nested logit model. We follow a common approach in the empirical literature by *assuming* that such an equilibrium exists for the parameter vector we estimate. See also Berry et al (1995), Goldberg (1995) and Feenstra and Levinsohn (1995) for a more detailed discussion of this issue.

[27] Alternatively, a "successive monopoly" model of manufacturers and dealers, as in Bresnahan and Reiss (1985), could be adopted. We are investigating this possibility in ongoing research.

i.e. $\sum_{j \in S_{smt}} q_{jmt}(p_{mt}) \leq D_{smt}$, where S_{smt} is the subset of models produced in location s for import into market m. In other countries (France, Germany, and the U.K.) the constraint is specified as a percentage of total sales, i.e. $\sum_{j \in S_{smt}} q_{jmt}(p_{mt}) / \sum_{j=1}^{J_{mt}} q_{jmt}(p_{mt}) \leq d_{smt}$. In both cases, the affected firms solve a constrained profit maximization problem. Solving this problem with respect to each car model j, we obtain the following set of J_{mt} first-order conditions in market m at time t:[28]

Markets with an absolute quota:

$$\sum_{k \in F_{fmt}} \left(e_{fmt} p^w_{kmt} - e_{fst} \frac{\partial C_{kt}}{\partial q_{kmt}} - e_{fst} \lambda^a_{smt} \right) \frac{\partial q_{kmt}}{\partial p^w_{jmt}} + e_{fmt} q_{jmt} = 0$$

Markets with a relative quota:

$$\sum_{k \in F_{fmt}} \left(e_{fmt} p^w_{kmt} - e_{fst} \frac{\partial C_{kt}}{\partial q_{kmt}} - e_{fst} \frac{\lambda^r_{smt}}{Q_{mt}} \right) \frac{\partial q_{kmt}}{\partial p^w_{jmt}} + e_{fst} \frac{\lambda^r_{smt}}{Q_{mt}} \frac{Q_{smt}}{Q_{mt}} \sum_{k=1}^{J_{mt}} \frac{\partial q_{kmt}}{\partial p^w_{jmt}} + e_{fmt} q_{jmt} = 0$$

where $Q_{mt} = \sum_{j=1}^{J_{mt}} q_{jmt}$ and $Q_{smt} = \sum_{j \in S_{smt}} q_{jmt}$. The Lagrange multipliers λ_{smt} are expressed in the currency of the source country (as is marginal cost). In the case of an absolute quota constraint, one may interpret λ^a_{smt} is as the shadow marginal cost of selling an additional car from source country s into destination market m. The multipliers are identified as source- and time- specific fixed effects; the larger the multiplier, the more binding the constraint is. If the firm does not face an import constraint, its first-order condition is given by equations similar to the ones above, but with the Lagrange multipliers set to zero.

This system of J_{mt} first-order conditions can be transformed into J_{mt} pricing equations, which decompose price into a marginal cost and a markup. This transformation is useful for both econometric and interpretation purposes, as it helps us understand the sources of price discrimination. Define, for each market/year, a J_{mt} by J_{mt} matrix, $\mathbf{\Delta}_{mt}$, whose (j,k) element is $\Delta_{jk,mt} = -\partial q_{kmt}/\partial p^w_{jmt}$ if j and k are produced by the same firm, and $\Delta_{jk,mt} = 0$ otherwise. Define $\mathbf{q}_{mt}$ as a J_{mt} by 1 vector with a j-th element equal to q_{jmt}, and $\mathbf{r}_{mt}$ as a J_{mt} by 1 vector with a j-th element equal to$(Q_{smt}/Q_{mt})(1/e_{fmt}) \sum_{k=1}^{J_{mt}} \partial q_{kmt}/\partial p^w_{jmt}$. After dividing the first-order conditions by e_{fmt}, write the system in vector notation and premultiply by $\mathbf{\Delta}^{-1}_{mt}$, the inverse of $\mathbf{\Delta}_{mt}$. This yields the following pricing equations (converted here into source currency units) for each model j in market m at time t:

Markets with an absolute quota:

[28] See Goldberg (1995) and Verboven (1996) for a detailed derivation.

$$e_{smt}p^{w}_{jmt} = \frac{\partial C_{jt}}{\partial q_{kmt}} + e_{smt}\boldsymbol{\Delta}^{-1}_{jmt}\mathbf{q}_{mt} + \lambda^{a}_{smt} \tag{14}$$

Markets with a relative quota:

$$e_{smt}p^{w}_{jmt} = \frac{\partial C_{jt}}{\partial q_{kmt}} + e_{smt}\boldsymbol{\Delta}^{-1}_{jmt}\mathbf{q}_{mt} + \frac{\lambda^{r}_{smt}}{Q_{mt}}(1 + \boldsymbol{\Delta}^{-1}_{jmt}\mathbf{r}_{mt}). \tag{15}$$

These pricing equations, together with the expressions for the market shares and the marginal costs discussed in the previous subsections, form the empirical model we take to the data.

Before we discuss the estimation procedure, it is useful to explain how this model can be used to identify the sources of international price discrimination. The pricing equations demonstrate that the price of each vehicle model can be decomposed in two components: its marginal cost, and a markup over marginal cost. Price differences that cannot be explained by differences in marginal costs across destinations, imply price discrimination. The markups are in turn determined by two factors: differences in the firms' perceived price elasticities of demand, and trade policies. The first factor is captured in the second term of the pricing equations by the own- and cross-price derivatives. These are in turn determined by the existence and intensity of competition. The subsection on the demand model provided more detailed intuition on the own- and cross-price derivatives. One testable hypothesis is that domestic firms face less competition than foreign firms. The second factor of price discrimination is captured by the Lagrange multipliers in the third term of the pricing equations. Binding quota in a particular country or year imply higher markups. Note that, since the quotas are based on imported units (and not on values), the markups of the inexpensive models will be relatively more affected than the markups of the luxury models if the quotas are binding. A third source of potential differences in the markups can be built into the model easily: differences in the degree of collusion. To this end, we can solve the model under alternative assumptions concerning strategic behavior, e.g. firms building different sets of coalitions in each market and engaging in joint profit maximization. Collusive behavior affects the way $\boldsymbol{\Delta}^{-1}_{jmt}$ is defined in (14) and (15).

The *evolution* of price discrimination can similarly be explained within the above framework. Local currency price stability can arise from a variety of factors. First, if estimation of the marginal cost function (12) indicates the presence of a significant local component in production costs, local prices will not fully respond to exchange rate shocks. Second, even without appealing to local production costs, the pricing equations (14) and (15) suggest the possibility of markup adjustment in response to cost shocks. This is indicated by several factors. First, the curvature of the perceived demand schedule is important. A firm's perceived demand elasticity for a particular model j may be increasing or decreasing in its own price and the price of its competitors. The precise shape of these elasticities is of course an empirical question; it depends on the model parameters to be estimated, the prices and the market shares. Second, the restrictiveness of import constraints may play a role. For example, quotas against Japanese firms may become less binding in a particular market as the Yen appreciates against the destination currency. Finally, to the extent that conduct affects the curvature of the perceived demand schedule, the degree of collusion may also have an impact on the degree of markup adjustment in response to cost shocks.

5 Estimation

5.1 The Estimation Method

The empirical model we take to the data consists of the market share equations (10–11) (in which the appropriate expressions for P_{ij} given by (7) and (8), or (7) and (9), are substituted), and the pricing equations (14–15), in which the marginal cost given by (12) is substituted. In this section we outline the procedure by which we estimate the parameters of these equations. For notational convenience, we again suppress the market and year subscripts m and t.

The error terms ξ_j and ω_j have the economic interpretation of unobserved product characteristics influencing the consumers' mean evaluation, and the producer's marginal cost for product j, respectively. Following Berry (1994) and Berry et al (1995), we proceed as follows: (1) we solve for the error terms ξ_j and ω_j as functions of the parameters and the data. This solution is derived numerically; due to the presence of the consumer specific income term y_i in the utility function, an analytical solution is not feasible. (2) we interact these error terms with a set of instruments to form a generalized method of moments estimator (GMM).

Consider the market share equations first. Collect the market shares s_j in a $Jx1$ vector s, and the mean utilities δ_j (including the one for the outside good δ_0), in a $(J+1)x1$ vector δ. Using (7) and (10), we can write out the system of J market share equations as a function of $J+1$ unknowns (the vector δ), and the parameters α and ρ, where $\rho \equiv (\rho_f, \rho_c)$:

$$s = s(\delta, \alpha, \rho).$$

Normalizing the mean utility of the outside good δ_0 to zero, one can invert this system to obtain a solution for δ:

$$\delta = \delta(s, \alpha, \rho).$$

Using (5), we obtain the following solution for the error term, written as a $Jx1$ vector ξ:

$$\xi = \delta(s, \alpha, \rho) - X\beta \equiv \xi(\alpha, \rho, \beta), \tag{16}$$

where ξ is a $Jx1$ vector of the error terms ξ_j, and X is a by JxK vector of characteristics. Let $\hat{\xi} = \delta(s, \hat{\alpha}, \hat{\rho}) - X\hat{\beta}$ be the sample analog of ξ, and Z a matrix of instruments, assumed to be orthogonal to the error term ξ. Then the moment conditions are given by:

$$E(Z \cdot \xi(\alpha, \rho, \beta)) = 0$$

and the GMM estimator minimizes the objective function:

$$\min_{\alpha,\rho,\beta} \hat{\xi}' Z \Omega^{-1} Z' \hat{\xi}, \tag{17}$$

where Ω is a weighting matrix.[29] This minimization problem involves a potentially large set of parameters. Fortunately, the computational burden can be reduced by observing that the parameters β enter linearly. This calls for the following two-stage procedure in estimating the demand parameters. First, derive the first-order conditions with respect to β. These yield:

$$\beta = (X'Z\Omega^{-1}Z'X)^{-1}X'Z\Omega^{-1}Z'\delta(s, \alpha, \rho),$$

Then substitute this expression for β into the objective function (17) using (16). This 2-step procedure offers the advantage that minimization of (17) is performed only with respect to the parameters that enter non-linearly: α and ρ. To implement this procedure we start with a guess for α and ρ, and solve for δ as a function of the data and our guess. Then we estimate the linear parameters β according to the formula given above. The estimates of β are substituted into (16) to form $\hat{\xi}$ which is then substituted into the objective function (17). Each iteration in the minimization algorithm yields new values for α and ρ which are then used to form new estimates of δ, β and ξ, and so on. The iterations continue until (17) is minimized.

Now consider the pricing equations (14–15). Since marginal cost enters additively, one can simply substitute (12) and slightly rearrange to obtain:

$$\ln((e_s p_j^w - e_s \mathbf{\Delta}_j^{-1}\mathbf{q} - \lambda_s^*)/F_s) = z_j\gamma_s + \delta \ln(W_s/F_s) + \zeta \ln Q_j + \omega_s + \omega_f + \omega_j, \tag{18}$$

[29] In the case of homoskedastic error terms, this matrix is equal to $Z'Z$.

where λ_s^* refers to either the absolute or the relative quota term. Since the error term enters linearly, estimation of this equation is straightforward.

The demand and supply systems can be estimated either jointly or separately.[30]We chose to estimate them separately, for several reasons. First, separate estimation of demand and supply reduces the computational burden of the estimation. Second, it gives us considerable flexibility in experimenting with different supply specifications, without having to re-estimate the demand system. This is important in our case given that our data set is rich enough to allow such experimentation, and that there are several specification issues on the supply side that need to be decided empirically, e.g., pooled estimation vs. country-by-country estimation, presence of local component and hence exchange rate effects in marginal costs, Bertrand competition vs. collusion, etc.. Finally, to the extent that the supply side may be misspecified, this would not affect the demand side results. The potential drawback of this procedure is of course efficiency loss; the standard errors of our parameters were, however, small enough to justify abstracting from efficiency issues.

5.2 Identification

Identification issues arise in the estimation of both the demand and supply sides of the empirical model. Consider the demand side first. The interpretation of ξ_j as unobserved product quality implies that it will be positively correlated with the product's price p_j; moreover, by virtue of the firms' first order conditions, it will also be correlated with the prices and market shares of the other products. Identification of the demand side parameters requires thus an instrumental variables matrix Z, with rank at least as large as the number of parameters to be estimated. Just as in the estimation of homogeneous product demand functions, variables that shift the producers' supply relations, but are excluded from the demand equations, make natural instruments. We therefore turn to equations (14) and (15) to identify potential instruments.

An obvious instrumental variable candidate indicated by the supply equations is the vector of exchange rates between a destination market and the source countries. As evident from the first order conditions (14) and (15), the function of exchange rates is to shift the supply relations of producers relative to each other; it is this shift that allows one to identify the demand curve suppliers face. The use of exchange rates as instruments presents two main advantages. First,

[30]When the two systems are estimated separately, the parameter estimates of the demand equations are used to form the matrix Δ of the own- and cross-price derivatives. This is then substituted into the left hand side of (18).

they can plausibly be considered exogenous to events in the auto industry. Second, they exhibit substantial variation from year to year. On the negative side, this variation is only helpful when we estimate the demand functions facing firms located in different countries; because two firms producing in the same country face the same exchange rates vis a vis any destination market, exchange rate shocks do not affect their supply curves relative to each other. Hence, to the extent that we want to estimate the demand curves facing *individual* firms, exchange rates are helpful, but not sufficient for identification. An additional limitation stems from the fact, that when market specific time dummies are included in the demand estimation, they absorb most of the variation associated with exchange rates; we found it necessary to include such dummies in our specification to account for macroeconomic effects that may affect the purchase of the outside good (that is the option not to enter the market).

A second set of instruments can be derived by exploiting the econometric exogeneity of the products' observed characteristics (the matrix X), along the lines suggested by the recent literature. The first option that comes to mind is to include a product's own characteristics x_j in the matrix Z ; this immediately reduces the number of the additional instruments needed for identification to the dimensionality of the vector (α, ρ). Second, the supply relations (14) and (15) suggest that prices and market shares depend on the degree and closeness of competition firms face. Accordingly, we can construct functions of the exogenous characteristics of competing products, that can be thought of as proxies for the intensity of competition firms face, and use those as instruments. These functions include the number and sum over characteristics of products sharing the same cluster (that is market segment and foreign/domestic status) and/or firm ownership with product j. The idea is that if competition in a particular cluster (as proxied by the number of products and sum of characteristics in this cluster) increases, the demand curve associated with a product in this cluster will become flatter; similarly, the greater the number of products a particular firm sells, the higher the price it will charge on each product.

A potential criticism of the above procedure is that both the process of entry in a particular cluster (that ultimately determines the number and characteristics of competing products) and the number of products a firm produces are themselves endogenous, as they will generally depend on the economic conditions of the industry. Note, however, that identification does not require the *economic* exogeneity of the entry process; we merely impose the assumption that the instruments listed above are uncorrelated with the *unobserved* quality ξ. Given that several market segment and firm dummies already capture the *observed* quality of the corresponding clusters, this assumption does not seem unreasonable.

In summary, the full set of instruments included in matrix Z contains: (1) A product's observed physical attributes x_{jmt}; (2) Exchange rates between source and destination countries, or market specific time dummies; (3) the sums of characteristics of other products belonging to the same cluster, and the number of products belonging to the same cluster; and (4) the sums of characteristics, and number of other products made by the same firm and belonging to the same cluster.

On the supply side, both the quantity Q_j and the quota terms (that are functions of the total car sales in each market) are likely to be correlated with the error term ω_j. In particular, a relatively low unobserved marginal cost ω_j would lead the firm to produce a higher quantity Q_j, implying that the quantity coefficient would be biased downward; similar arguments apply to the quota terms. Of course, to the extent that Q_j refers to product j's *world* sales, and not the individual sales in each market, the simultaneity bias is accentuated. Nevertheless, given that for some products, sales in the five countries in our sample constitute a large proportion of total sales,[31], it is important to instrument for the quantity and the quota terms. The list of instruments we use on the supply side includes, in addition to all exogenous variables in (18), the log of the product's sales in markets other than the five we consider in the estimation (as long as these sales are positive), a dummy variable if the sales in other markets are zero, and interactions of Japanese product and destination market dummies.

5.3 Accounting for Heteroskedasticity and Autocorrelation

Given that in our data each model appears in several years and multiple markets, it is important to account for potential heteroskedasticity and autocorrelation of the error terms in the estimation procedure. To this end, we considered two alternative procedures. The first one is to average the sample moment conditions across time, as suggested by Berry et al (1995), to obtain the moment conditions for each model in each market. This method allows for arbitrary heteroskedasticity and autocorrelation patterns in the error terms, but is not necessarily efficient. The second approach is to impose a particular covariance structure, and use that in computing the weighting matrix Ω and the standard errors. We considered the following structure that we believe is plausible within the context of our application:

The unobserved quality ξ_{jm} for product j in market m is assumed to follow a first order

[31]This is especially the case with products produced by firms registered in one of the sample countries; for example, a large fraction of products produced by Italian firms is sold in Italy.

autoregressive process:

$$\xi_{jm,t} \;=\; r_m\, \xi_{jm,t-1} + u_{jmt}$$

with $E(u_{jmt}) = 0$, $E(u_{jmt}^2) = \sigma_{jm}^2$, $E(u_{jmt}, u_{jms}) = 0$ for $t \neq s$, and $\|r_m\| < 1$, while

$$E(\xi_{jmt}, \xi_{j'mt}) \;=\; 0 \; for \; j \neq j^{'}$$

This specification, though restrictive, has the advantage of parameterizing the covariance structure in a way that allows for heteroskedasticity and serial correlation that declines geometrically over time, while limiting the number of additional parameters that need to be estimated.

A-priori, it is not clear which of the two methods is more efficient. We experimented with both, and did not find a significant difference in the results (in both cases all parameters were very precisely estimated). The results we report below are derived using the second method.

6. Results

6.1 Summary of Estimation Results

Demand: In the estimation of the demand parameters we experimented with two alternative models: one based on equation (8) (the nested logit), and one based on equation (9) (the generalized extreme value model). The results we obtained by estimating the second system, however, did not support the structure we had imposed. The estimation algorithm almost always converged to ρ values well outside of the unit interval; the only exception was France where the estimates were consistent with the restrictions implied by utility maximization. Based on these results we had to conclude that the generalized extreme value model is simply not supported by the data for the automobile market. In contrast, the results we obtained by estimating the nested logit were very reasonable, so we concentrated on that specification.

This subsection provides a brief overview of the demand estimation results; the implications of these results for price discrimination are explored in more detail in the next section. Table 5 provides a summary of the relevant coefficients and their standard errors.

The demand system was estimated separately for each country. Most of the coefficients were significantly different across countries, thus supporting the separate estimation against pooling of the data. However, inspection of the coefficients relating to price and physical car characteristics indicated the existence of collinearity. To mitigate the impact of collinearity on the results, we averaged these coefficients across countries, using the inverse of the variance of each coefficient as a weight.[32] Accordingly, Table 5 reports only one price coefficient (α) for all countries.

In general, all coefficients (including the ones not reported in the table, such as the coefficients on physical car characteristics and time dummies) had the expected signs and were very precisely estimated. The time dummies for each country are plotted in Figure 6; these capture preference for autos relative to the outside good, and can thus be thought of as proxies for macroeconomic effects that affect the likelihood of purchasing a new car. It is interesting to note that the time pattern of the dummies traces the business cycle in each country; the low time dummy values in the early 1980's, for example, coincide with the recession in European countries, the positive trend between 1985 and 1990 coincides with the rising income in these countries, and the decline of the Italian time dummies after 1990 coincides with the recession in Italy. These results are reassuring as their plausibility provides some indirect support for the estimated specification.

Of particular interest are the country dummies reported in Table 5, that capture preferences for cars originating from a particular country. In all four countries in which there is domestic production, consumers have a distinct preference for domestic cars, as indicated by the higher coefficient for the domestic brands in each country.[33]

The other noteworthy coefficients are the ρ's, that capture the correlation pattern of the error terms within each cluster. For each country there are two ρ coefficients, one corresponding to the distinction between foreign and domestic (ρ_f), and one corresponding to the distinction between market segments (ρ_c).[34] Only in Belgium there is a single ρ coefficient as there are no Belgian domestic brands, so the model reduces to a one-level nested logit, with the nests representing

[32] Alternatively, we could have estimated the demand system by pooling the data for all countries, imposing the same price and car attribute coefficients for all countries, and letting the ρ's and the origin dummies being country specific. This specification would have been appealing, as it implies that consumer preferences for various car attributes do not vary across markets, but there may be unobserved factors (proxied by the country dummies and captured by cross-country differences in the ρ's) that account for differences in the demand patterns. We did not pursue this alternative, because pooling of the data exceedingly complicates the covariance structure. Our procedure of averaging (using appropriate weights) the coefficients potentially affected by collinearity is, however, similar in spirit to the alternative just described.

[33] For example, in France the largest country dummy is the one for French cars; in Italy for Italian cars, etc.. The country coefficients capture preferences relative to the U.K.; accordingly, the negative coefficients in the U.K. column indicate that cars from countries other than the U.K. are valued less than British cars.

[34] We also experimented with specifications in which the ρ coefficients were allowed to be market segment specific; this makes the model more flexible. In all five countries, however, we failed to reject the hypothesis that the ρ's were equal across different market segments, so we adopted the reported specification with only two ρ coefficients.

different market segments. Note that the ρ parameters generally satisfy the restrictions imposed by utility maximization; they lie in the unit interval, and ρ_c is greater than or equal to ρ_f. The only exception is Germany, where $\rho_c < \rho_f$; note, however, that the Wald test does not reject the hypothesis that the two coefficients are equal in this country. The other interesting case is the one of Italy; the coefficient ρ_c is equal to 1 there, implying that the model reduces to a one-level nested logit, in which each nest includes cars of the same market segment and the same domestic/foreign status. In short, we can summarize the pattern that emerges from Table 5 with regard to the demand structure as follows: In Belgium the demand model reduces to a one-level nested logit, as there are no domestic brands. In France and the U.K. the demand structure is described by a two-level nested logit, with market segments and foreign/domestic representing the two levels of nesting. In Italy and Germany the model again reduces to a one-level nested logit, but the nests look different in the two cases: in Italy products compete closely only with products of the same market segment and origin; in Germany, products compete closely with products of the same market segment irrespective of whether these products are foreign or domestic. As we will see in the next section, these differences in the nesting structures suggested by our estimation results have implications for the substitution patterns, prices and market power in each country.

Costs: The results from estimating the pricing equation (18) are summarized in Table 6. In the reported specifications we pooled the data for all countries, imposing the same coefficients on physical characteristics; we also estimated separate pricing equations by producing country, but the coefficient estimates were not statistically different across countries, while the point estimates were generally similar to the ones in Table 6. In columns 1 and 2 we report the results that were obtained by assuming Bertrand competition in all five countries. All parameters have the expected signs and are precisely estimated. The positive coefficient of the foreign firm dummy indicates that foreign firms face a cost disadvantage. The size and significance of the source country log wage coefficient indicate that marginal cost is sensitive to labor costs, i.e., there are few substitution possibilities towards other production factors. Note also the coefficient on the log of the world production quantity for each model (LQU). The negative point estimate is consistent with the existence of increasing returns to scale. Note, however, that in most specifications this coefficient is not statistically significant and its magnitude is quite small. We should note that when we estimated the pricing equation with OLS (hence ignoring the potential endogeneity of the quantity and the quota variables), we obtained a substantially larger (in absolute value) and statistically significant quantity coefficient (estimate of -0.02 with a t-statistic of -7.95). This is consistent with our expectations; if there exists an unobserved component in marginal cost that causes quantities to be large when costs are low, then we would expect the OLS estimate to be biased downwards. A coefficient similar to the OLS estimate was also obtained when the model was estimated without model fixed effects. Intuitively, when model fixed effects are not included in the estimation, increasing returns are identified solely off the cross-section variation in quantities; models with large market shares are associated with lower marginal costs. Including fixed effects has the effect of removing from the error term unobserved factors that may induce spurious correlation between cost and quantity, and identifying increasing returns off the time variation in quantity of each model.

Of interest are also the year quota variables for Japanese cars. As Table 6 indicates, these are jointly significant at any reasonable significance level. Figure 7 plots the estimated quota effects for each country; the estimates have the interpretation of Lagrange multipliers, thus capturing the restrictiveness of quantity constraints in each market. The plots are intuitive and consistent with our expectations. In almost every year the quota effects are highest for Italy, the country with the most stringent import constraints; Italy is followed by France, and then the U.K. and Germany, where the estimates were not statistically significant. A comparison of Figure 7 with the data on Japanese quotas reported in Table 1 (line 6) suggests that this order corresponds exactly to the shares allocated to the Japanese imports in each country. Another interesting pattern that emerges from Figure 7 is that in each country the estimated Lagrange multipliers are highest in years in which the Yen depreciates against the local currency. This is intuitive as a weaker Yen strengthens the position of Japanese producers, hence making the import constraint more binding.

As indicated by Table 6, our estimated specifications include the log of the exchange rate between the source and destination country on the right hand side. Under the hypothesis that marginal costs in each country do not contain a local component, the exchange rate coefficient should be zero. A positive coefficient indicates that some fraction of the marginal costs occur in local currency, so that when the exporting country's currency appreciates against the importing country's currency, costs denominated in exporter currency go up. This result obviously has implications for the degree of local currency price stability; we explore those in detail in the next section. Since the results of the pricing-to-market regressions in section 3.3 indicated a higher degree of local price stability in the U.K., we also experimented with a specification in which the exchange rate is interacted with a U.K. dummy (column 2). The estimated coefficient is statistically significant, but too small in magnitude to support the hypothesis that marginal costs in the U.K. are affected by exchange rate changes by more than in other countries.

Note finally the estimated fixed effects for each country. Their relative magnitudes are plausible as they imply that unobserved costs are highest in the U.K. and Germany, and lowest in Belgium. The obligatory use of catalytic converters in Germany is consistent with these estimates. Regarding the U.K. fixed effect, it is common wisdom that cars in the U.K. are better equipped than in the rest of Europe due to the existence of a well developed market for company cars.[35] In addition, dealer discounts are reportedly larger in the U.K. than in the other countries.[36] Since our estimation employs list prices, differences in discount practices across countries manifest themselves as differences in the country fixed effects in the cost equations. The right-hand drive regulation may also contribute to higher costs. Another line of interpretation for the high fixed effect in the U.K. could focus on differences in firm behavior, e.g., collusion in the U.K. Apart from the magnitude of the cost fixed effect, the U.K. stands out as the only European country in which the Monopolies and Merger Commission initiated a legal investigation for collusive behavior. This prompted us to explore the possibility of collusion in the estimation of the supply side of the model.

To this end, we reestimated the pricing equation (18) assuming collusion in the U.K., and Bertrand competition in the other four countries. As noted before, the assumption of collusion changes the matrix Δ of own and cross-price derivatives in equation (18). The results from this specification are reported in column 3 of Table 6. Ideally, we would like to employ a goodness-of-fit statistic to distinguish between the two alterative models, Bertrand vs. collusion. Both models, however, explain the data quite well and seem indistinguishable in terms of their fit. Therefore we escorted to an alternative way of assessing their relative merit: examine the estimated coefficients under the two specifications and assess which ones appear more plausible. Note that the coefficients in columns 2 and 3 of Table 6 are almost identical, except from one: the fixed effect for the U.K., which drops from 0.18 in the Bertrand specification to 0.05 in the collusive one. Intuitively, all the assumption of collusion does, is blow up the estimated markups for the U.K., hence suppressing the magnitude of marginal costs. Nevertheless, while the U.K. fixed effect estimate appeared too high under Bertrand, it seems too low under collusion, given

[35]The U.K. National Consumer Council (1990) reports that between 55 percent and 60 percent of all new cars sold in the U.K. are bought by a company or as a business expense. In Germany and France, company cars account for around 15 percent of sales.

[36]B.E.U.C. and the U.K. Monopolies and Mergers Commission report discounts of up to 15% in the U.K. compared to a maximum of 10% in other countries. For company cars discounts are less well documented, but the U.K. Monopolies and Mergers Commission reports that discounts to fleet customers probably vary between 16 and 22% percent.

the anecdotal evidence pertaining to better equipped cars and higher discounts in the U.K.. Given these results, it is impossible to make a definitive statement as to which behavioral assumption is more appropriate for the U.K., even though it seems that some type of behavior that is more collusive than Bertrand, but less collusive than joint profit maximization might produce the most plausible fixed effects estimates.

6.2 The Sources of Price Differentials

Having estimated the demand and supply parameters of the model, we now return to the question we posed at the beginning: Why are prices so different across European countries? Our estimation results suggest three main factors contributing to systematic price differences.

The first factor is differences in the demand patterns, and in particular, the existence of a strong bias for domestic brands. This bias manifests itself in two forms in our estimation results. First, the country dummies in the demand estimation (see Table 5 and the discussion in the previous section) unambiguously demonstrate the existence of a strong preference for domestic cars in each country. Second, the differences in the nesting structures, indicated by the differences in the relative magnitudes of the ρ parameters, also have implications about the intensity of competition between domestic and foreign brands.

Consider France and the U.K. first, the two countries in which the bi-nested logit structure is supported by the ρ estimates. The estimation results imply that consumers view products of the same domestic/foreign status as closer substitutes than products of different origin. Hence, when the price of a domestic (foreign) product goes up, they are more likely to substitute towards another domestic (foreign) product in the same class, than switching to a car of a different nationality. This pattern is to be contrasted with Germany, where domestic and foreign products are viewed as equally likely substitutes as long as they belong to the same market segment. In Italy, on the other hand, the domestic/foreign distinction is even more relevant for consumer behavior than in France and the U.K.; cars here compete closely only with products that share the same market segment and the same domestic/foreign status. From the consumer's point of view, a German subcompact lies as far from an Italian subcompact, as a German luxury car.

The implications of these estimates for the substitution patterns are summarized in Table 7, that lists the average own and cross-price elasticities of demand in each market. Note that with the exception of Germany, the average price elasticity of demand for foreign cars is always

– consistent with the existence of a home bias – higher than the corresponding elasticity for domestic cars. This pattern is most pronounced in Italy which also has the lowest average price elasticity. The importance of the domestic/foreign distinction for consumer behavior in each market is also reflected in the pattern of the cross-price elasticities; in all markets but Germany the average cross-price elasticities between any two domestic (or foreign) cars are higher than the cross-price elasticities between domestic and foreign. This pattern is again much more pronounced in Italy than in the other countries.

What are the implications of these differences in demand patterns for price dispersion? Recall that the price of an automobile in each country can be decomposed into a marginal cost and a markup component. The differences in elasticities translate into differences in the cross-country markups. The average relative markups (Lerner indices) are listed in the bottom part of Table 7; again, they are broken down by foreign/domestic.

The one thing that strikes one immediately when comparing average markups across countries, is that markups in Italy are substantially higher than in the other countries. In comparison, markup differences across the other countries are relatively small; in France, for example, markups are on average only by 2% higher than in Belgium, while in the U.K. the difference goes the other way, and markups are by 2% lower. Overall, however, these differences are too small to generate economically significant price differences. In contrast, markups in Italy generate a 14% difference in prices relative to Belgium. As evident from the last two rows of Table 7, the high markups in Italy are primarily driven by the market power of domestic producers; foreign car markups are approximately of the same magnitude as in the other countries.

Why does preference for domestic cars generate such a high degree of market power in Italy? The answer seems to lie in the fact that Fiat occupies an almost monopoly position in Italy. The substitution patterns implied by our estimates suggest that when the price of a domestic car goes up, consumers are more likely to switch to another domestic car. But while in other countries the substitute car may belong to a different firm, in Italy it is very likely produced by the same firm, namely Fiat. It is this combination of home bias and a near monopoly position of the domestic firm that seems to generate market power in Italy. In short, it appears that differences in the price elasticities of demand, that translate into differences in markups, can explain a significant fraction of the price differentials in Italy relative to other countries. This explanation however does not seem to fit the other expensive country in our sample, the U.K., where the price elasticities of demand seem to be going the wrong way: they imply lower, and not higher prices, even though the difference is not statistically significant.

The second factor that generates price dispersion in the five European countries in our sample is the differential impact of the quota constraints. These appear much more restrictive in Italy and France than in the other three countries. The higher prices of Japanese cars in Italy and France could hence be attributed to the quota constraints. To assess to what extent these constraints also affect the prices of the other cars in each market, we reestimated the pricing equation (18) for each country, omitting the Japanese year/quota variables. The resulting increase in the fixed effect estimates for each country can be interpreted as the overall price (or shadow marginal cost) increase generated by the existence of import constraints. According to our results, this increase is approximately 2% for France, 1% for the U.K., and 0.5% for Italy.[37] In Germany, quota constraints do not affect costs or prices; this is of course to be expected given that the Lagrange multipliers estimated for Germany were insignificant in all years. The small impact of the quota constraints on overall costs and prices in Italy may seem surprising at first, given that the Lagrange multipliers for Italy were significantly higher than for any other country in our sample. Note, however, that due to the extremely restrictive quota allocated to Japanese imports in Italy (1%), the fraction of cars that are affected by the quota is very small (namely ca. 1% of the market). Hence, while the prices of Japanese cars are significantly higher in Italy than in the rest of Europe, their share in total sales is too small to drive the overall higher prices documented in Italy.

The third factor generating price dispersion in Europe is unobserved costs, as proxied by the country fixed effects in the pricing equation. These were discussed in detail in the previous section, and it was shown that their magnitudes were generally plausible and consistent with industry wisdom. Of particular interest is the U.K. fixed effect. Recall that our descriptive analysis at the beginning of the paper demonstrated the two countries with the systematically higher prices are Italy and the U.K.. While the demand side of the model can explain the higher prices in Italy, it fails to account for the high prices in the U.K.. The latter are explained entirely by the supply side. As discussed earlier, it is impossible to determine on the basis of our results whether the high fixed effect estimate for the U.K. is due to better equipped cars and higher dealer discounts, or collusive behavior.

In summary, our estimation results suggest that approximately 20% of the cross-country price differentials can systematically be explained by structural demand side (in Italy) and

[37] All these figures are very precisely estimated, with t-statistics ranging from 6 to 20.

supply side (in the U.K.) factors, that are unrelated to exchange rate variation.[38] Nevertheless, cross-country price differentials in each year tend to be significantly higher, approximately 30% of the average car price as shown in the introduction. Hence there remains a 10% difference to be explained. Our descriptive results in section 3.3. suggested that exchange rate volatility plays an important role in year-to-year changes in price differentials. Therefore we now turn to a more systematic investigation of the implications of our estimates for local currency price stability.

6.3 Local Currency Price Stability

To understand the implications of our results for local currency price stability, it is instructive to compare the pricing equations (14) and (15) to the pricing-to-market equation (2) we estimated at the beginning of the paper. In the pricing-to-market literature, only prices and exchange rates are observed; accordingly, the challenge for the researcher is to find a way to decompose the price variation into a component that reflects movements in the marginal cost, and a component that reflects movements in the markup, without actually observing either marginal cost or markup. As discussed in section 3.3, this is achieved by testing for correlation of export prices with exchange rates, while controlling for common across markets changes in marginal costs through time effects, and product quality differences and/or constant markups through country fixed effects.

Compared to this approach, the advantage of estimating a fully specified model of supply and demand is that it allows us to estimate the exact markups and marginal costs in each market and each year. This is evident from equations (14) and (15); prices denominated in exporter currency can now explicitly be decomposed into a marginal cost component ($\frac{\partial C_{jt}}{\partial q_{kmt}}$), the markup ($e_{smt}\boldsymbol{\Delta}_{jmt}^{-1}\mathbf{q}_{mt}$), and a third component that is related to the existence of import constraints. The pricing-to-market regressions established that local currency prices remain relatively stable when exchange rates fluctuate, so that a 1% change in the exchange rate between an exporting and an importing country leads to a 0.46% change in the exporter currency price. In this section we investigate the determinants of this local currency price stability; is it driven by changes in the marginal cost, or does it reflect markup adjustment?

[38]In particular, the combined results of Tables 6 and 7 suggest that in the U.K., 18% of the price differential relative to Belgium can be attributed to unobserved fixed costs, while 1% is due to quota constraints; in Italy, 14% is attributed to differences in the markups, 5% to unobserved costs and 0.5% to the quotas; in Germany, 14% is attributed to cost differences, and in France 2% is attributed to markup differences, 5% to cost differences, and 2% to the impact of the quota constraints.

The results of the estimation of the pricing equation reported in Table 6 speak directly to this issue. Recall that when the exchange rate between the producing and the destination country was included in the specification, the estimated coefficient was positive and highly significant. This suggests the presence of a local component in marginal costs. Moreover, this component appears to be economically significant. The point estimate of the exchange rate coefficient is 0.31, implying that a 1% appreciation of the exchange rate of the exporting country against the currency of the destination market changes costs denominated in *exporter* currency by 0.31%. This is a large effect, and naturally the question arises whether it is plausible.

To get a rough idea about the plausibility of this estimate, we went back to industry sources and reports of the European Commission to collect some information about the importance of local costs. Industry wisdom is that local costs are up to 35% of the value of a car.[39] Even though this number is vague and hard to confirm, it gives us some idea about the order of magnitude of exchange rate effects on costs. In particular, suppose that markups remained constant during periods of exchange rate volatility; then it is easy to show, using the firms' first order conditions, that the expected effect of a modest exchange rate change on costs would be *around* 35%.[40] Even though, in the absence of specific cost information, we are not able to make more precise statements regarding the magnitude of the local component in marginal cost, it seems safe to say that the 31% coefficient the pricing equation estimation yields, appears plausible.

The implications for local currency price stability are then straightforward. Out of the 46% adjustment of the export prices that the pricing-to-market regressions estimated, 31% can be attributed to a change in marginal costs caused by the exchange rate movement. The remaining 15% are due to markup adjustment. While this number is high, it is significantly lower than the original 46% suggested by the pricing-to-market results.

An alternative way to assess the extent of markup adjustment is to examine how the price elasticities of demand change in response to price movements within our model. To this end, we computed the derivative of the absolute value of the elasticity with respect to price; consistent

[39]See, for example, De Financieel Economische Tijd, January 15, 1998, for a reference to this number. This relatively high number can be partly explained by the presence of many small dealers.

[40]We put emphasis here on the word *around*. Note that the statement that local costs are about 35% of the value of the car, is itself inconsistent during periods of exchange rate volatility, as exchange rate changes affect the proportion of local costs in total costs. One way to interpret this statement is that exchange rate movements are not too large, so that the proportion of local costs, even though affected by the exchange rate change, remains roughly of the same order of magnitude as before.

with our expectations, we consistently found this derivative to be positive, indicating that elasticities are increasing in price. In a further step, we also computed an analytical approximation to the effect that a 1% cost increase would have on percentage markups within our model, in the absence of a local component in marginal costs; this effect was on average -0.15, though there was substantial variation across models. This again, is consistent with our previous results on the magnitude of the pricing-to-market coefficient and the impact of exchange rates on costs.

Even though we plan to investigate the exact effects of exchange rates on prices in more detail in a future paper using simulations, a clear picture already emerges: Exchange rate fluctuations are not fully passed through on local prices, and have hence a significant impact on cross-country price dispersion. This inertia of local currency prices can be attributed to a large extent to the existence of a local component in marginal costs; this component accounts for approximately 2/3 of the change in export currency prices caused by exchange rate movements. The other 1/3 is due to markup adjustment that can in turn be traced back to changes in the perceived elasticities of demand during periods of exchange rate volatility.

7. Conclusion

In this paper we set out to investigate the sources of price dispersion in European countries paying particular attention to the role of exchange rates. Our results suggest that across the 14 years of our sample, there is an average price difference of 20% between the U.K. and Italy, and the cheapest country in our sample, Belgium. This price difference is attributed primarily to cost and discount differences in the U.K., and to price discrimination related to the existence of domestic brand bias in Italy. Around this 20% mean, there are substantial fluctuations from year to year, with cross-country price differentials becoming as large as 35-40% in individual years. These fluctuations can be attributed to the incomplete response of local currency prices to exchange rate changes. The local currency price stability reflects both the existence of a local component in marginal costs, and price discrimination (markup adjustment) that is correlated with exchange rate volatility.

If one were to judge the effects of the impending EMU on price dispersion based on these results, one would conclude that the EMU will very likely eliminate the year-to-year volatility observed in our data, but cross-country price differences will not completely disappear without further measures to harmonize requirements and promote integration. Of course, given that local currency prices tend to exhibit stability over time, the particular levels at which exchange rates will be fixed at the outset of the EMU, will be important. In 1993, for example, the exchange rate parities were such, that price differentials were almost eliminated across countries. By 1998, the U.K. has again become substantially more expensive than the rest of Europe. If exchange rates remained fixed at the current level in the future, the U.K. would likely remain more expensive.[41]

With the EMU a few months away, these predictions will of course be soon put to a test. The EMU will provide an unprecedented experiment for the purpose of assessing the role of exchange rate in generating cross-country price dispersion. But the actual data required to evaluate the effects of this experiment are at least a few years away. We hope that this exercise will provide some useful insights in the mean time.

[41]On the other hand, the U.K. will not yet be part of the EMU in 1998.

FIGURE 1

Price Dispersion in the European Car Market
Figure 1a

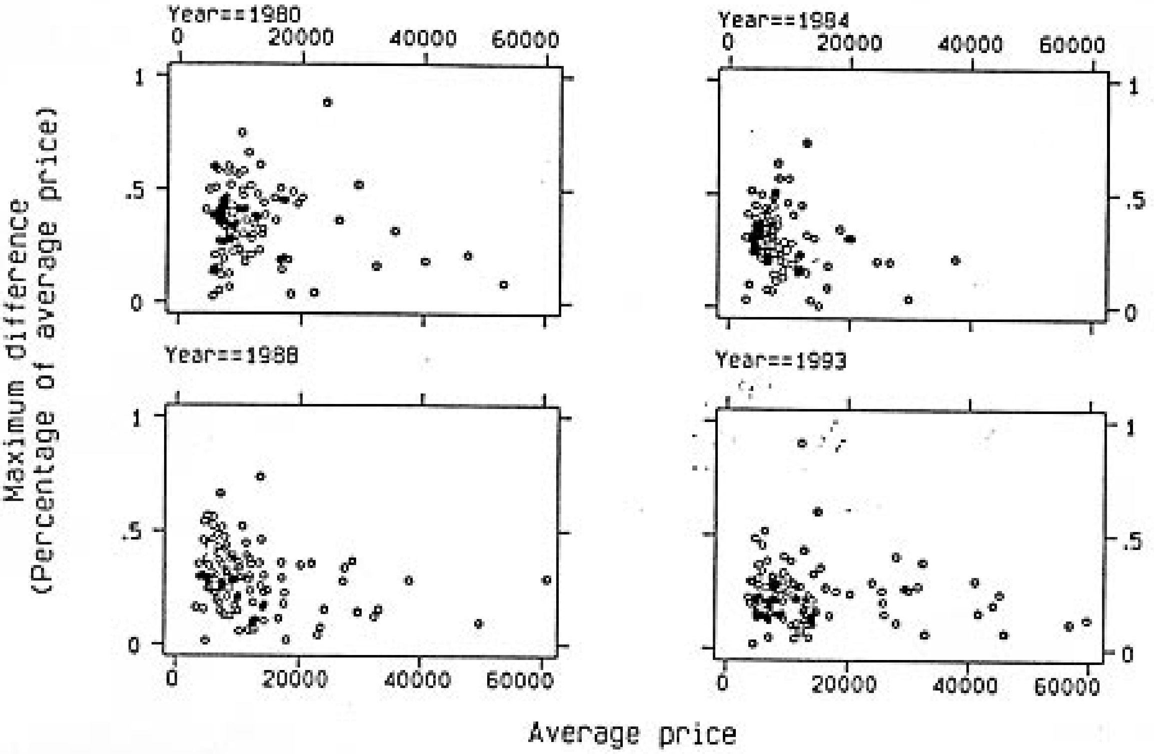


Figure 1b

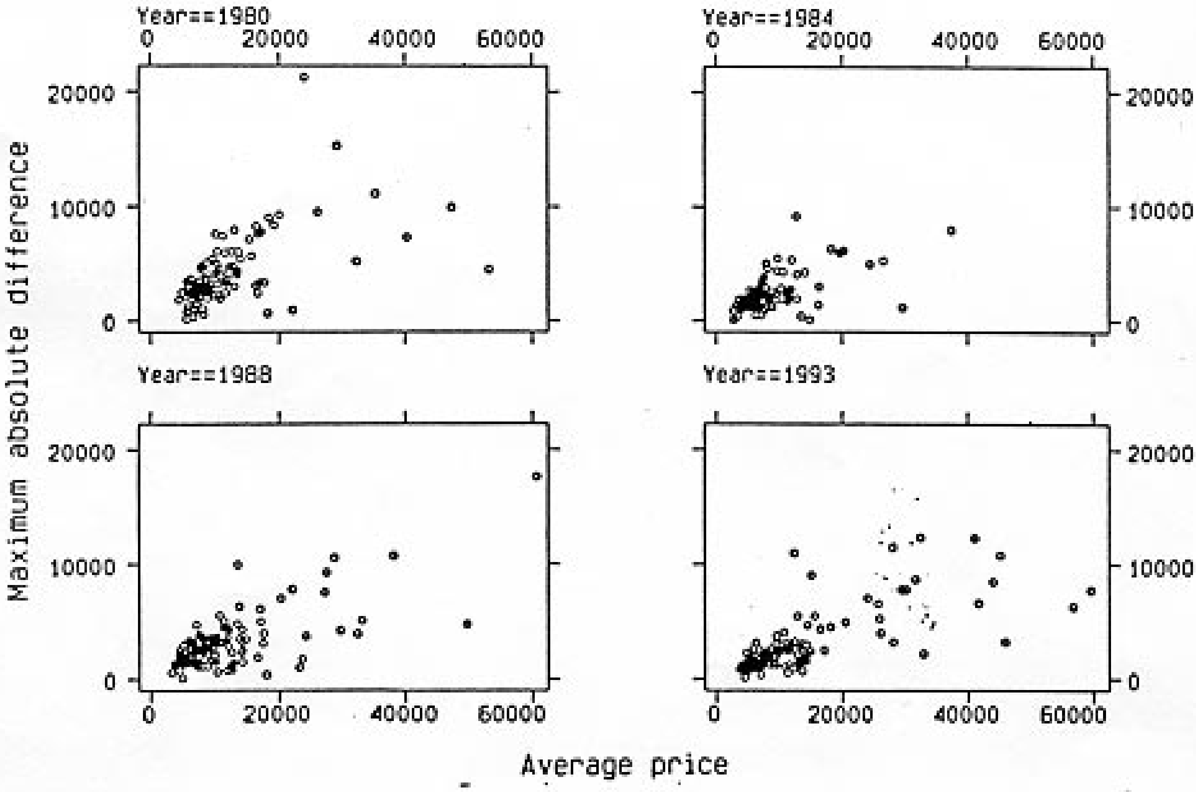
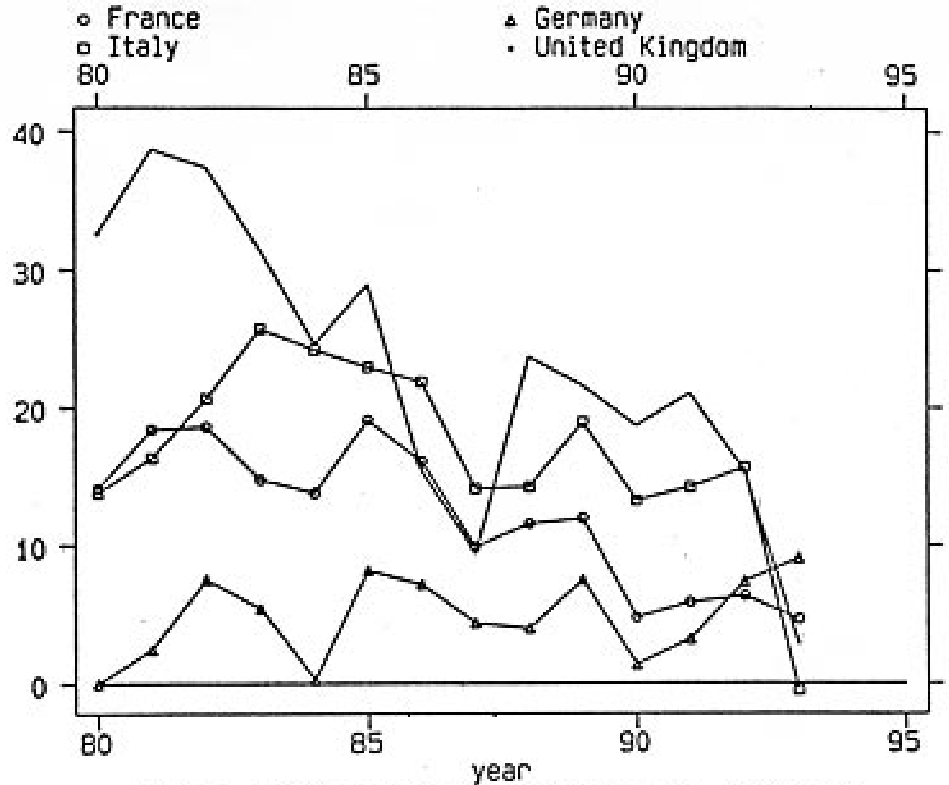
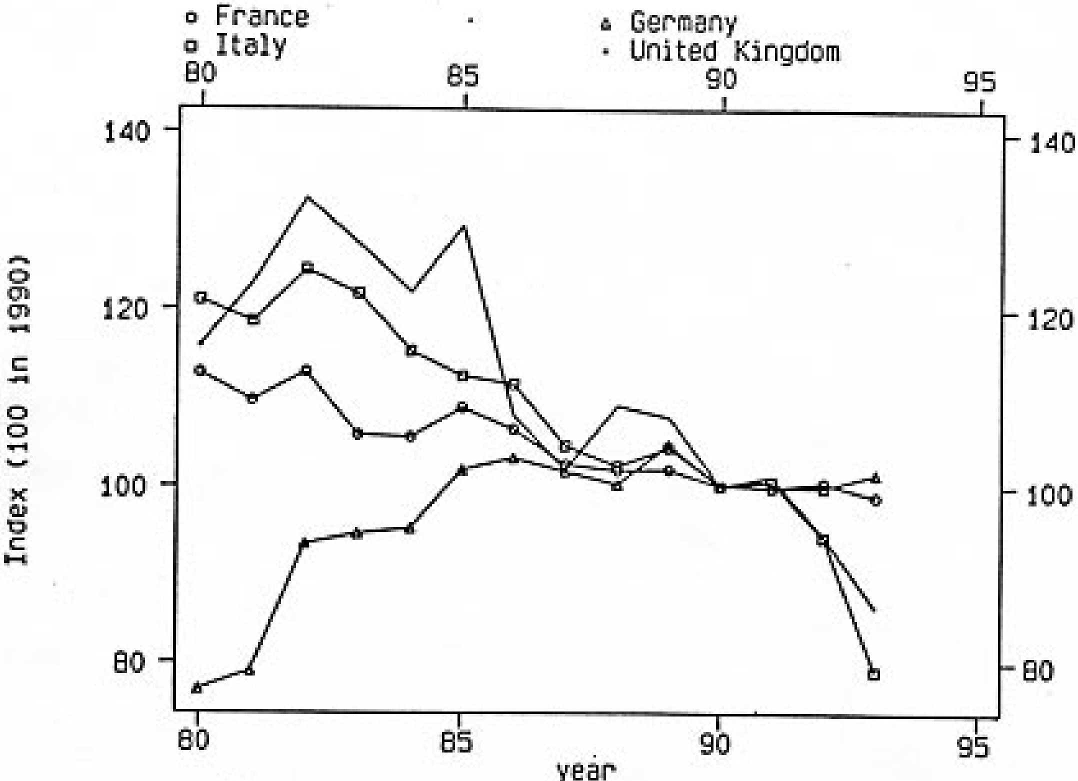


FIGURE 2



Price differences relative to Belgium

FIGURE 3



Exchange rates relative to Belgium

FIGURE 4

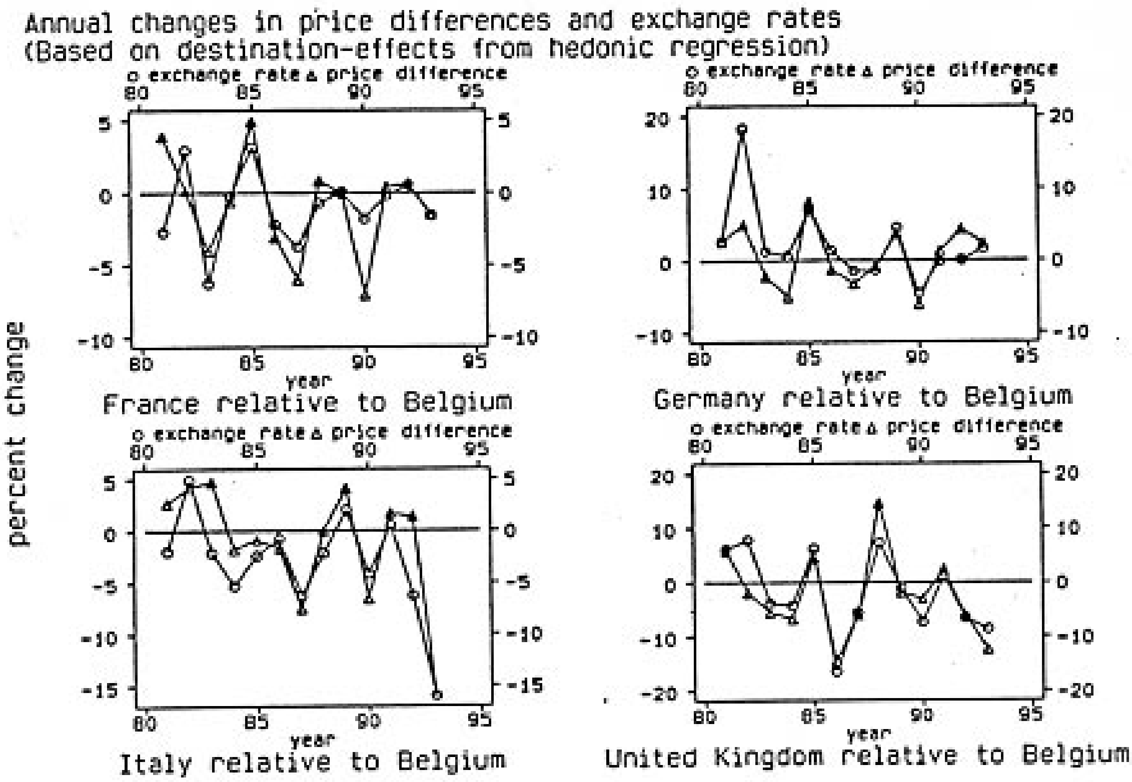


FIGURE 5

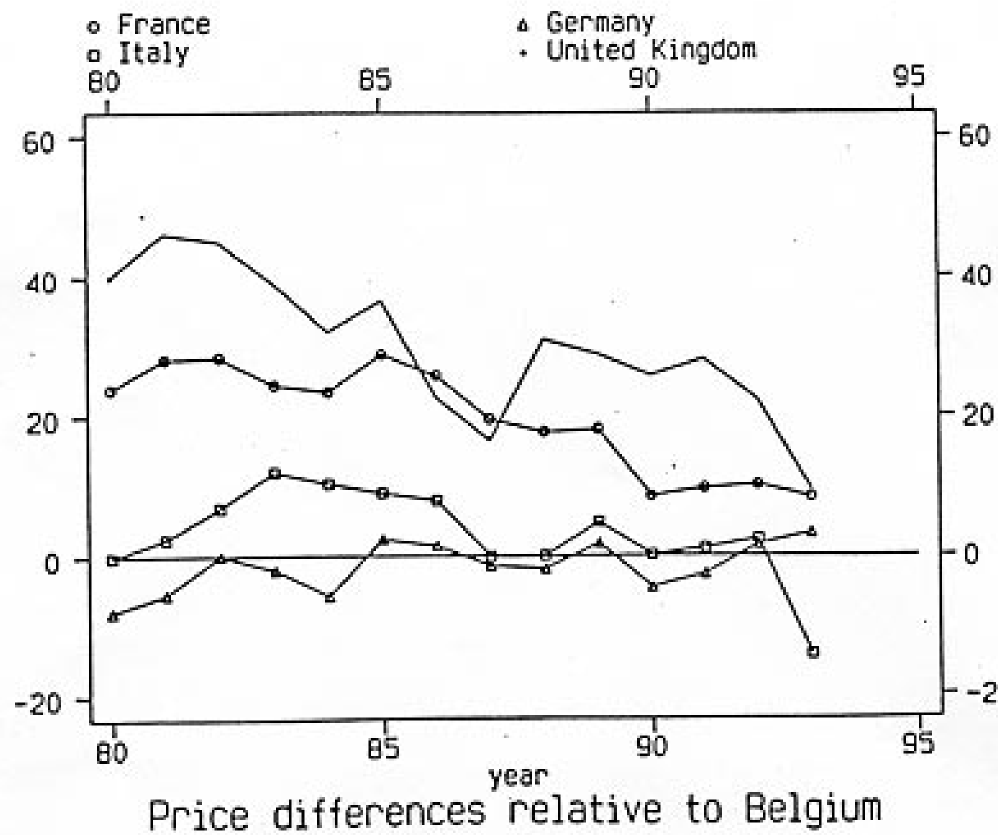
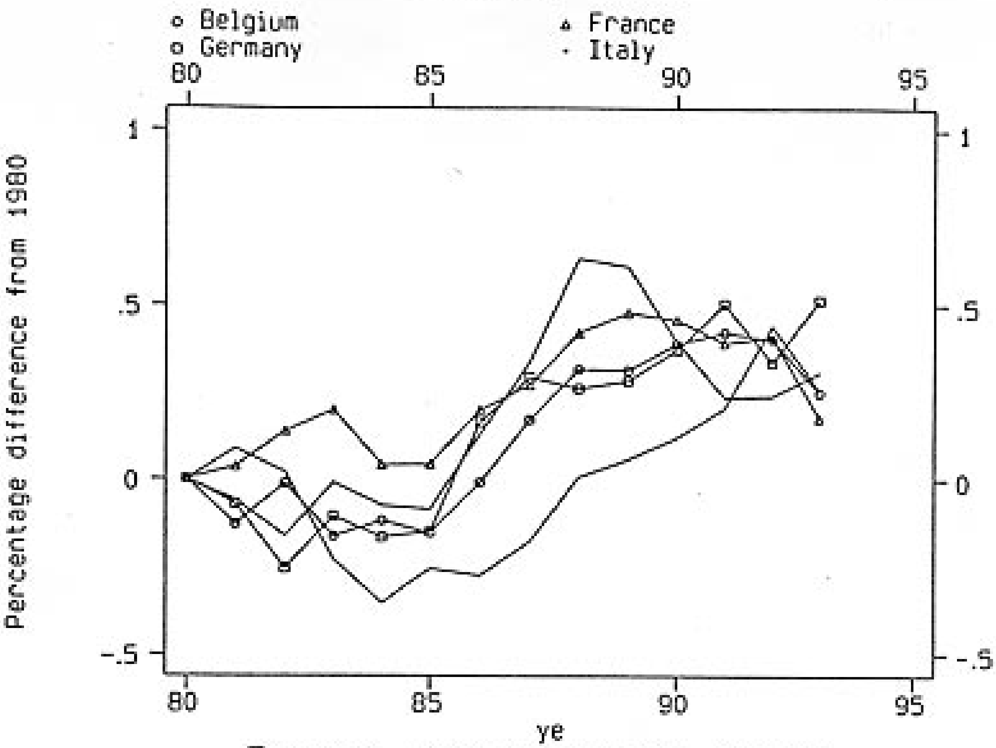
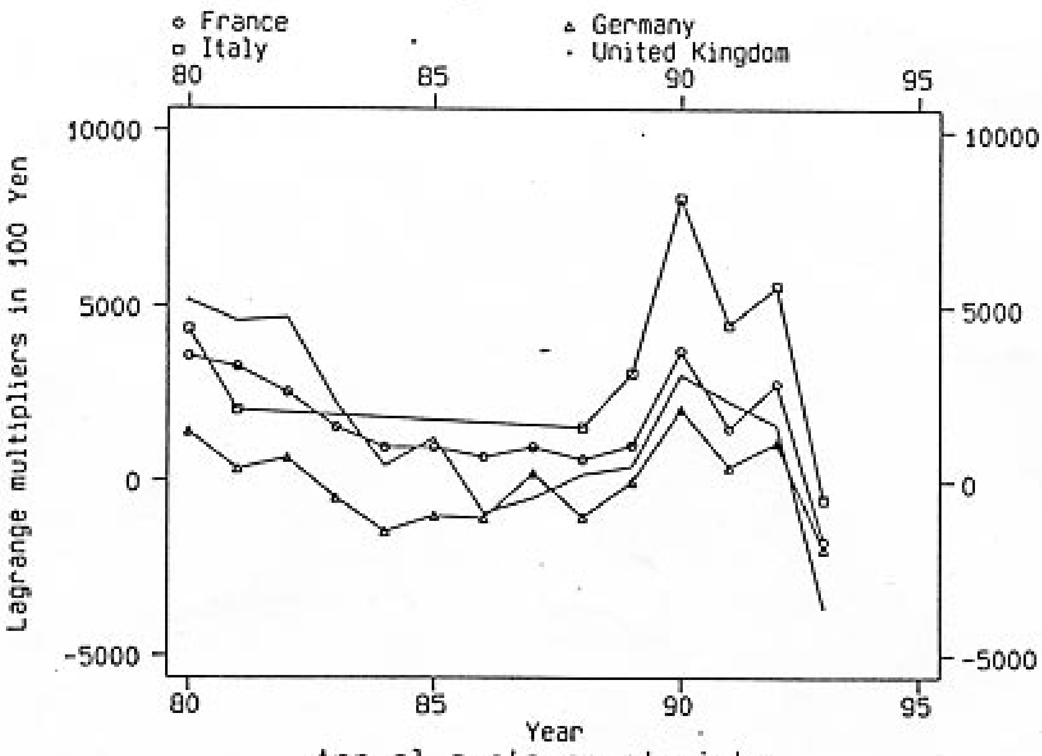


Figure 6



Economy-wide changes in demand

Figure 7



Annual quota constraints

Table 1: **Summary Statistics for the European Car Market** *

	BE	FR	GE	IT	UK	ALL
1980 value-added tax (in %)	25	33	13	18	23	
1990 value-added tax (in %)	25	25	14	19	24	
Total sales (in 1,000 units)	384.4 (48.9)	1920.3 (192.1)	2508.9 (359.7)	1908.0 (293.4)	1704.1 (248.9)	8412.3 (892.4)
Parallel imports (in 1,000 units)	N/A	5–40	30–60	10–75	1–50	
Japanese market share (in %)	21.6 (1.9)	3.1 (.5)	15.5 (1.5)	1.8 (1.3)	11.3 (.6)	7.7 (1.0)
Japanese quota (in %)	—	3.0	15.0	1.0	11.0	
Domestic market share (in %)	2.5 (.4)	66.6 (5.1)	70.2 (4.0)	58.2 (6.2)	55.1 (4.0)	
European average (in %)	1.6 (.5)	24.6 (2.6)	33.4 (1.9)	16.7 (1.4)	12.1 (1.5)	
C1-ratio (in %)	16.3 (1.8) (VW)	33.5 (1.7) (PSA)	30.2 (1.2) (VW)	53.9 (5.2) (Fiat)	28.7 (3.3) (Ford)	15.7 (1.6) (Fiat)

* Annual averages over 1980-93. Standard deviations in parenthesis.

Table 2: **Hedonic Price Regressions**

Dependent variable: log(price) in ECUs
Number of Observations: 7212

Variable	Coefficient (Std.)	Coefficient (Std.)
Constant	7.9562 (.0794)	7.6668 (.0784)
Horsepower	.0076 (.0001)	.0076 (.0001)
Weight	.0003 (0)	.0003 (0)
Width	.0051 (.0004)	.0051 (.0004)
Height	-.0011 (.0003)	-.0011 (.0003)
Log value-added tax	.0526 (.0250)	-.1561 (.0229)
Exr	-	.0207 (.0037)
Mini	-.5119 (.0142)	-.5119 (.0142)
Small	-.4171 (.0121)	-.4171 (.0121)
Medium	-.3438 (.0111)	-.3438 (.0111)
Large	-.2546 (.0094)	-.2546 (.0094)
Executive	-.1493 (.0088)	-.1493 (.0088)
Luxury	-.2142 (.0102)	-.2142 (.0102)
Sports (normalized)		
Firm dummies	*p*-value: .0000	*p*-value: .0000
Source / time dummies	*p*-value: .0000	*p*-value: .0000
Market / time dummies	*p*-value: .0000	*p*-value: .0000
R-squared	.97	.97
Durbin-Watson statistic	1.78	1.82

Table 2 continued: **95% Confidence Interval for Destination Effects***

Country \ Year	1980	1985	1990	1992	1993
France	10–18	16–22	2–8	3–9	2–7
Germany	–	4–12	(-3)–5	3–12	5–13
Italy	11–17	19–27	10–16	12–19	(-3)–2
United Kingdom	30–36	26–32	16–22	13–19	(-3)–5

* Based on hedonic price regression, column 1 of Table 2. All numbers are percent deviations from the hedonic prices in Belgium that are normalized to zero every year.

Table 3: **Pricing-to-market Coefficients**
(by source country and destination market)

$$\beta_{sm} = \beta_s + \beta_m$$

$$\beta_{sm} = 1 \Rightarrow \text{ mbox}$$

$$\beta_{sm} = 0 \Rightarrow \text{ mbox}$$

	Be	Fr	Ge	It	Ja	Ko	NL	Sp	Sw	UK
β_s	.4176	.4445	.2478	.5684	.2017	.2096	.1632	.7395	.6905	.7910
	(.2582)	(.0574)	(.0556)	(.0664)	(.0687)	(.3528)	(.2800)	(.1918)	(.1172)	(.0977)
S_s	.01	.25	.33	.17	.07	.001	.005	.028	.01	.12
β_m		.0281	−.0757	−.0132						.2024
		(.0338)	(.0470)	(.0420)						(.0360)

Table 4: **Convergence Results**

	Full sample		1980–90		1987–93		1987–91	
Conv	−.06	−.07	.06	−.04	−.36	−.06	−.24	−.02
	(.04)	(.02)	(.06)	(.03)	(.08)	(.04)	(.09)	(.04)
Δ mbox	—	−.84	—	−.81	—	−.90	—	−.96
		(.04)		(.06)		(.06)		(.09)
R^2	.04	.86	.03	.82	.36	.91	.22	.88

Table 5: **Results from the Demand Estimation**
(selected coefficients)

(Standard errors in parenthesis)

	Be	Fr	Ge	It	UK
Number of observations	1351	1196	1077	1027	1221
ρ_f	.39	.31	.42	.45	.35
	(.12)	(.06)	(.10)	(.07)	(.06)
ρ_c	—	.56	.39	1.01	.44
		(.11)	(.13)	(.23)	(.14)
α	125.9	125.9	125.9	125.9	125.9
	(9.6)	(9.6)	(9.6)	(9.6)	(9.6)
Wald-statistic for $\rho_f = \rho_c$	—	5.34	.16	5.77	.31
Preference for:					
France	.37	.95	.69	.39	−.65
	(.32)	(.15)	(.25)	(.15)	(.11)
Germany	.99	.38	1.68	.65	−.15
	(.36)	(.11)	(.45)	(.17)	(.10)
Italy	.76	−.01	.70	1.25	−1.06
	(.30)	(.09)	(.24)	(.25)	(.18)
Japan	.70	−.08	.74	−.45	−.90
	(.30)	(.08)	(.28)	(.21)	(.14)
Spain	.07	−.12	.47	.21	−1.58
	(.32)	(.16)	(.32)	(.24)	(.25)
Sweden	1.01	−.01	.89	.64	−.61
	(.34)	(.11)	(.27)	(.24)	(.14)

Table 6: **Results from Estimation of the Pricing Equation***

	Bertrand	Bertrand	Collusion in UK
Constant	-4.62	-4.60	-4.81
	(1.23)	(1.23)	(1.26)
Foreign firm disadvantage	.04	.04	.03
	(.47E-02)	(.48E-02)	(.49E-02)
France fixed effect	.06	.06	.06
	(.56E-02)	(.56E-02)	(.58E-02)
Germany fixed effect	.14	.14	.14
	(.59E-02)	(.59E-02)	(.61E-02)
Italy fixed effect	.05	.05	.05
	(.74E-02)	(.74E-02)	(.76E-02)
UK fixed effect	.19	.18	.05
	(.70E-02)	(.72E-02)	(.73E-02)
LHW	1.42	1.43	1.45
	(.05)	(.05)	(.05)
LWI	8.60	8.58	8.98
	(.92)	(.92)	(.94)
LHE	3.23	3.21	3.18
	(.81)	(.81)	(.83)
LQU	-.38E-02	-.31E-02	-.68E-02
	(.30E-02)	(.30E-02)	(.31E-02)
LWAGE	.36	.36	.37
	(.04)	(.04)	(.04)
LEXR	.31	.31	.31
	(.02)	(.02)	(.02)
LEXRU	—	-.40*E*-02	-.01
		(.18E-02)	(.18E-02)
Time dummies	*p*-value: .00	*p*-value: .00	*p*-value: .00
Model fixed effects	*p*-value: .00	*p*-value: .00	*p*-value: .00
Japanese quota year dummies	*p*-value: .00	*p*-value: .00	*p*-value: .00

* Acronym explanation:

LHW:	log of horsepower / weight
LWI:	log of width
LHE:	log of height
LQU:	log of world production quantity
LWAGE:	log of wage of the producting country
LEXR:	log of exchange between source and destination country (source currency units / destination currency units)
LEXRU:	*LEXR* * Dummy for the UK

Table 7: Substitution Patterns and Markups in the 5 European Countries (in 1990)

	Be	Fr	Ge	It	UK
Average price elasticity $\left(\frac{\partial \ln s_i}{\partial \ln p_i}\right)$	–5.77	–5.60	–5.74	–4.09	–6.21
for domestic cars $\left(\frac{\partial \ln s_i^d}{\partial \ln p_i^d}\right)$	–5.77	–5.37	–6.09	–3.63	–6.03
for foreign cars $\left(\frac{\partial \ln s_i^f}{\partial \ln p_i^f}\right)$	—	–5.98	–4.96	–4.51	–6.45
Average cross-price elasticity $\left(\frac{\partial \ln s_i}{\partial \ln p_j}\right)$	.035	.047	.035	.029	.040
for domestic cars $\left(\frac{\partial \ln s_i^d}{\partial \ln p_j^d}\right)$	.035	.170	.015	.111	.076
for foreign cars $\left(\frac{\partial \ln s_i^f}{\partial \ln p_j^f}\right)$	—	.054	.033	.038	.044
between domestic and foreign $\left(\frac{\partial \ln s_i^d}{\partial \ln p_j^f}\right)$	—	.015	.043	.220E-05	.030
between foreign and domestic $\left(\frac{\partial \ln s_i^f}{\partial \ln p_j^d}\right)$	—	.024	.036	.913E-05	.025
Average markup	0.19	0.21	0.19	0.33	0.17
Average markup for domestic cars	0.19	0.22	0.18	0.40	0.17
Average markup for foreign cars	—	0.18	0.22	0.23	0.16

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