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Direct and indirect price discrimination in the automotive industries of the European Union

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Abstract Using a panel dataset comprising of 51 models across 21 European Union member states, I estimate the effects of country-specific factors that make price discrimination profitable. Taking advantage of cross-country heterogeneities, I find that a domestic brand bias, per capita income, and income inequalities lead to significantly different prices across borders. The role of income inequalities is supported by a theoretical model of indirect price discrimination at the national level. We therefore conclude that not only direct international price discrimination, but also indirect national price discrimination is responsible for the observed price differentials across international borders, which are not likely to fully converge as long as the exclusive dealership system is in place, and significant demand-side differences still remain.

Keywords Price dispersion · Price discrimination · Price convergence

JEL Classification L11 · L41 · L62

1 Introduction

When analyzing prices of different products across international borders, one can often observe large and persistent differences. This contradicts the idea that in a world with no trade frictions, arbitrage forces should lead to a convergence in prices. These deviations from the law of one price have been traditionally associated with exchange rate fluctuations, costly arbitrage, non-homogeneous products, different local distribu-

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tion and retail services, trade and geographical barriers, and other institutional factors that effectively translate into cost differences. Different costs automatically lead to different prices, and this is true even under perfect arbitrage conditions.[1] All these supply-side-based arguments sparked large waves of trade liberalization talks and agreements, but in spite of all this, price dispersion can still be observed on many international markets.

A demand-side-based hypothesis needed to be formulated and tested. The idea that manufacturers could, in fact, price strategically across destination markets according to local demand conditions generated a whole new strand of literature and pointed to some very important issues. Among these, probably the most important one is that, when considering strategic pricing issues, we need to focus on specific industries rather than considering macrolevel baskets of goods and price indexes. For strategic pricing to be possible, manufacturers need to be able to segment the markets successfully. Significant demand-side characteristics need to be present, and free arbitrage needs to be prevented. All these factors are very different across industries; hence, the analysis should focus more on the microlevel and consider specific markets rather than the whole economy. As Knetter (1993) shows, pricing to market explains price dispersion across a large number of products and countries, but the main source of variation comes from industry-specific effects. This proves that in some industries, strategic pricing is more prevalent than in others. Arbitrage forces, for instance, are very different across industries. A specific example, provided by Knetter (1997), is the observed price dispersion for *The Economist*. This example shows that the lack of arbitrage opportunities is often obvious even if it cannot be quantified. In the specific case, the time-sensitive nature of the product makes it extremely difficult for potential resellers to make any profits from arbitrage.

This paper takes into account these points and focuses on a specific industry—the European auto manufacturing industry—where the role of exchange rate fluctuations is eliminated (at least in the Euro zone), and where a very prohibitive exclusive dealership system is in place, which allows for market segmentation and price discrimination.

2 The European automobiles market

Even before there was a European Union (EU), but especially after its creation, people have been concerned with the obvious price differences for similar or identical car models across countries. Studies conducted by the European Bureau of Consumers Unions between 1980 and 1995 showed that large price volatility for automobiles across European countries was a long persistent problem. Pretax prices for nearly identical models were found to vary by up to 90 percent. Europe is geographically-wise very concentrated, hence any differences in transportation costs from the manufacturing country to the destination country should not matter that much. The European Union is designed to function as a single, central market with no trade restrictions of any kind. The population is also fairly uniform with respect to their preference for car specifications and features. In a competitive environment, prices should reflect production costs, and

[1] See Krugman (1991), Eaton and Kortum (2002).

therefore, they should depend on the characteristics of the cars. Judging by all these facts, one would expect prices to be fairly uniform across European borders. However, this is not even close to the market reality.

Mertens and Ginsburgh (1985) were among the first to ask what are the factors that can explain these differences in prices. They found both product differentiation and market imperfections to be significant. However, product differentiation could only explain a smaller part of the variation. The larger part was not explained by any physical or technical characteristic and could only be attributed to price discriminatory practices. We argue that the importance of product differentiation has gone down even more since their study in 1985. With the EU integration, there has been a significant convergence in terms of the hedonic indexes across countries, as all member states had to implement uniform standards of safety and pollution. Models became more and more similar in terms of physical characteristics. Nowadays, models are virtually identical across countries, with only minor differences present, such as right-hand side driven cars in the UK. This technical convergence has brought price dispersion down since the early years of the EU, but a significant level still persists.

A different approach was based on a price-leadership model in Kirman and Schueller (1990). However, their model fails to explain how a certain producer might become dominant on any given market. Ignoring the demand side and solely focusing on cost aspects will not paint a complete picture. It is extremely likely in fact that it is the demand-side aspects that can strengthen the position of a producer on a given market.

Verboven (1996) showed that price dispersion was getting smaller as the EU was moving toward more integration, but was still at a significant level. He pointed to different price elasticities across countries resulting from a preference for domestic brands, to import quota constraints present in some countries, and finally to the possibility of collusion. The possibility of collusion was also documented by Radoias (2015). Continuing on the topic, Goldberg and Verboven (2001, 2004, 2005) bring other factors into discussion, such as the effects of local currency stability and the importance of exchange rates on local cost differences.

This paper follows the literature on strategic pricing and points that not only direct international price discrimination can result in price dispersion, but also indirect price discrimination inside a given country can have similar results. We show in a simple model how different income distributions result in different prices across countries and then use data from recent years to validate these predictions. We also acknowledge the fact that many factors considered to be relevant in the past are no longer an issue. We can no longer think of import quotas for instance—they have been completely eliminated. Starting with the year 2000, the European Union banned all import quota restrictions for this particular industry. Also, in the Euro zone, there are no longer exchange rate fluctuations of any kind. The fact that price dispersion went down as a result of these institutional changes is well documented in Goldberg and Verboven (2005) and also in Gil-Pareja and Sosvilla-Rivero (2008). However, today there are still significant differences in prices across member states in the Euro zone—more than 30 percent for some models as we can see in Table 1.

The figures in the table represent price differences for a selection of best selling cars, expressed as percentages of prices in Euro (excluding taxes), comparing the most expensive market with the cheapest one. They were published by the European

Table 1 Price differences in the Euro zone

	2008 (%)	2007 (%)	2006 (%)
Small segment			
Peugeot 206/207	32.6	24.9	18.7
Renault Clio	23.4	19.1	15.3
Ford Fiesta	21.4	20.2	16.3
Fiat Punto	21.4	17.5	18.6
VW Polo	25	25.4	13.4
Medium segment			
VW Golf	24.3	25.2	23.4
Ford focus	27.4	23.8	28.5
Renault Megane	17.3	19.2	22.3
Opel Astra	18.4	24.8	24.8
Peugeot 307	34.8	31	21.2
Large segment			
W Passat	17.1	20.3	22
BMW 320D	12	9	5.5
Audi A4	7.4	13.9	12.7
Peugeot 407	15.2	15.9	14.3
Mercedes C	11.9	12.1	5.6

Commission in 2008, and they only include countries in the Euro zone. It is very easy to see that, for many of the best selling models, price dispersion actually went up between 2006 and 2008. This is fundamentally opposing the theory that market integration reduces price dispersion. We argue that, whatever portion of the past observed price dispersion was due to trade barriers and restrictions, it has already been eliminated with the integration efforts. The remaining price differences can only be explained by strategic pricing and are not likely to disappear, as long as demand conditions remain different across countries.

A remark needs to be made about the presence and importance of local costs. It has been argued that up to 35–40 % of the final cost of a car is represented by local, dealer-related costs, and that these cost differences are the reasons behind the observed price dispersion. Based on easily accessible online data on manufacturer suggested retail prices (MSRP) and invoice prices, one can easily conclude that these figures are highly exaggerated. These estimates are based on opinions of “inside experts”, and no rigorous study to estimate these local costs exists. Unfortunately, it is impossible to correctly measure and estimate these effects without private dealership data. In Goldberg and Verboven (2001), an attempt has been made to proxy these costs using the log of the wage rate, and the corresponding coefficient has been found to be statistically significant. However, given the close correlation between wage rates and per capita income, this might be a cost-related effect or solid proof of direct price discrimination based on purchasing power. Or, more likely, it might be a compounded effect. Since we cannot precisely distinguish local cost differences from higher purchasing power, we cannot fully reject the presence of different local costs. However, these local costs cannot account for the full variation in prices, and therefore, our strategic pricing arguments are still valid.

Two major things need to be discussed, without which price discrimination could not be employed—market power, and the ability to prevent resales. The automobiles manufacturing industry is highly concentrated, and entry barriers are high. Seven corporate groups control over 70 percent of the European markets for passenger cars.[2] The largest three groups (Volkswagen, PSA, and Renault) control over 45 percent of the entire market. It goes without saying that this degree of market concentration gives manufacturers the ability to easily control prices.

On the other hand, resale prevention is achieved through the use of the exclusive dealership system. With the introduction of the open borders policy,[3] practically anyone could go in the neighboring country and buy a car if it is cheaper. In fact, some do that. But these are the exceptions that confirm the rule, as for the average customer the transaction costs to buy abroad are still higher than the eventual profits coming from price differences.

However, large firms could buy and sell automobiles on a large scale and profit from that. So why is this not happening? The answer might lie in the fact that manufacturers sell their cars and offer maintenance and warranty services exclusively through authorized dealers. Car manufacturers do not sell cars directly to consumers nor offer maintenance and repair services. Instead, they operate a dealership franchise system that offers both the product, and maintenance and repair services to consumers. These dealerships are privately owned, but strongly kept in check by the manufacturer.

The anticompetitive practices associated with this exclusive dealership system go to the point where manufacturers explicitly forbid the dealers to sell to foreign customers or to offer service for cars bought abroad. At the same time, many manufacturers void the car's warranty if it is being serviced at a non-authorized dealer. There were numerous antitrust actions taken by the European Commission with the intention of discouraging the use of such practices. The Volkswagen group has been fined 102 million ECU in 1998,[4] Daimler-Chrysler got a similar fine of 72 million Euros in 2001,[5] and Peugeot had to pay 49.5 million Euros in 2005 for employing such anticompetitive practices.[6] In spite of all this, the exclusive dealership system is still in place today all over the world and still achieves the same major role—preventing arbitrage and allowing for market segmentation and price discrimination.

Today, the manufacturing groups claim that their dealership system respects all the EU norms and is merely a means of providing better customer care. However, with such a tainted history, one can argue that many consumers are still afraid of servicing their cars at a non-authorized dealer or buying a car abroad. Therefore, the dealership system, while not legally preventing arbitrage, is still at least slowing it down.

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[2] Volkswagen, PSA Peugeot Citroen, Renault, General Motors, Ford, Fiat, and BMW combine for about 73 % of the European market share.

[3] Directive 2004/38/EC of the European Parliament recognizes the right of citizens of the Union and their family members to move and reside freely within the EU territory. At the same time, Article 30 of the Treaty on the Functioning of the European Union (TFEU) prohibits member states from levying any duties on goods crossing a border.

[4] EC Case IV/35.733—VW.

[5] EC Case COMP/36.264—Mercedes-Benz.

[6] EC Cases COMP/E2/36623, 36820, and 37275—SEP and others/Automobiles Peugeot SA.

3 A model of indirect price discrimination

In this section, we present a standard indirect price discrimination model in which we show that international price differences exist not only because of direct price discrimination across borders, but also because in any given country, manufacturers price discriminate indirectly and different income distributions result in different incentive compatible prices. We present a simple two types model that is easily tractable and intuitive, but these types of second-degree price discrimination models can be generalized without any qualitative changes.[7]

Formally, we assume a country populated by individuals of two types: premium and regular buyers. A manufacturer has a choice between uniform pricing and price discriminating between these two types of consumers. Because the manufacturer cannot distinguish a premium buyer from a regular buyer, direct price discrimination cannot be employed. However, indirect price discrimination is not only possible, but also extremely common on auto markets. Virtually, every auto manufacturer offers a variety of models and options for consumers to choose from. For our model, assume a manufacturer can offer two models: a high-quality model (designed for high-type buyers) and a regular model (designed for regular buyers). Assume without loss of generality that there are no costs of production.[8] High-type buyers have higher income and are therefore willing to pay more for any given model, so regular buyers are only willing to pay some fraction of what high-type buyers are willing to pay. Formally, let the high-type buyer's valuations be V_h for the high-quality model, and V_r for the regular model, while the regular buyer's valuations be αV_h and βV_r, for the high-quality, and regular model, respectively. Naturally, both α and β are parameters on the unit interval, $V_\mathrm{h} > V_\mathrm{r}$, and $\alpha V_\mathrm{h} > \beta V_\mathrm{r}$. For price discrimination to work, we also need the monotone likelihood property assumption $\alpha < \beta$. The intuition of this assumption is that the differences in types are much larger for high-quality products. High-type buyers are more likely to pay higher markups for premium products. Assume there are N total buyers, and ϕ is the proportion of high-type buyers on the market. The manufacturer has to choose an optimal pricing scheme to maximize profits.

Consider first a uniform pricing strategy. The manufacturer only offers the high-quality model to both types of consumers and charges either V_h (if he only wants to sell to high-type buyers) or αV_h (if he wants to sell to both types). The choice depends on the relative magnitudes of ϕ and α, which is suggestive of the trade-off between higher prices and lower sales. The resulting prices and optimal profit will be:

$$\begin{cases} P = V_\mathrm{h} & \text{and} \quad \Pi_{\mathrm{Uniform}} = \phi \mathrm{NV_h} \ \text{ if } \phi > \alpha \\ P = \alpha V_\mathrm{h} & \text{and} \quad \Pi_{\mathrm{Uniform}} = \alpha \mathrm{NV_h} \ \text{ if } \phi < \alpha \end{cases}$$

Consider now a second-degree price discrimination strategy. The manufacturer offers both models and sets prices P_h and P_r for the high-quality and regular model,

[7] See Wilson (1993).

[8] Costs do not affect the functional form of the incentive compatible prices, but only the firm's profitability. Costs can therefore influence the price discrimination regime, but in a way that does not change the qualitative effects of the other parameters.

respectively. These prices need to be incentive compatible and individually rational for buyers. Formally, the manufacturer has to choose a pair of prices that solve the maximization problem:

$$\begin{aligned} \underset{P_h, P_r}{\text{Maximize}} \quad & \Pi_{\text{Discrim}} = \phi \text{NP}_h + (1-\phi)\text{NP}_r \\ \text{subject to:} \quad & V_h - P_h \geq 0 \\ & \beta V_r - P_r \geq 0 \\ & V_h - P_h \geq V_r - P_r \\ & \beta V_r - P_r \geq \alpha V_h - P_h \end{aligned}$$

which yields the optimal incentive compatible prices: $P_r = \beta V_r$ and $P_h = V_h - V_r(1-\beta)$. The resulting profit for the manufacturer, if he decides to price discriminate, is $\Pi_{\text{Discrim}} = \phi N(V_h - V_r) + \beta \text{NV}_r$. These results have the usual intuition of the trade-off between attracting more sales from the low end of the market and leaving rents on the table for the high-end consumers, in order to preserve the incentive compatibility. Naturally, the manufacturer has to evaluate the profitability of price discrimination versus uniform pricing. Depending on the values of the parameters, the optimal pricing strategy is given by:

$$\begin{cases} P = \alpha V_h \text{ (uniform pricing)}, & \text{if } 0 < \phi < \frac{\alpha V_h - \beta V_r}{V_h - V_r} \\ P_h = V_h - V_r(1-\beta) \text{ and } P_r = \beta V_r \text{(price discrimination)}, & \text{if } \frac{\alpha V_h - \beta V_r}{V_h - V_r} < \phi < \beta \\ P = V_h \text{ (uniform pricing)}, & \text{if } \phi > \beta \end{cases}$$

True comparative statics cannot be performed for all parameters, over the entire range of values. Prices depend on parameters on any given price discrimination regime, and at the same time, parameters jointly determine the regime. We can summarize, however, the effects of parameters on prices (for any given regime) and also for the cutoff that determines the regime.

First of all, on any give regime, prices are increasing in consumers' valuation V. There are two valuations in the theoretical model (V_h and V_r), which affect prices in the same direction, and so we treat them as one. Also, prices are increasing in α and β, depending on regime, except for the third regime. However, the third regime is never observed empirically. More specifically, for small values of ϕ, we enter the first pricing regime, which dictates that prices increase with α. On the other hand, for medium values of ϕ, we enter the second pricing regime, where prices increase with β.

The pricing regime is jointly determined by all parameters. A higher α leads to a higher likelihood of being under the first regime, which implies lower prices. This, however, only matters for non-extreme values of ϕ. A higher β leads to a higher likelihood of moving from the first regime to the second, which implies higher prices, but also to a higher likelihood of moving from the third regime to the second, which implies lower prices. Parameter ϕ dictates which of these two will occur—small values of ϕ will lead to a positive effect on price, while large values of ϕ will lead to a negative effect on price. Finally, a larger ϕ will lead to lower product variety and price discrimination, and hence to higher prices, but only if α and β do not take extreme values. For instance, if α and β approach 1, we get the first pricing regime no matter what ϕ is. We summarize all these comparative statics results as follows:

- Cutoff Effects
  - $\phi \uparrow \Rightarrow P \uparrow$, for medium values of ϕ
  - $\alpha \uparrow \Rightarrow P \downarrow$, for medium values of ϕ
  - $\beta \uparrow \Rightarrow \begin{cases} P \uparrow, \text{for small values of } \phi \\ P \downarrow, \text{for large values of } \phi \end{cases}$
- Direct Price Effects
  - $V \uparrow \Rightarrow P \uparrow$
  - $\alpha \uparrow \Rightarrow P \uparrow$, for small values of ϕ
  - $\beta \uparrow \Rightarrow P \uparrow$, for medium values of ϕ

We will test the predictions of this model, using data from the European automotive industry. This empirical exercise will directly point to some of the causes of price differentials that are linked to strategic pricing. Even in the absence of empirics, the model is still suggestive, by pointing to a previously unexplored cause of price dispersion, which is strategic pricing inside national territories that has direct repercussions in terms of international price dispersion.

3.1 Empirical model

Following the theoretical model, we can write down a reduced form empirical model by linking the theoretical variables to the available data. From the theoretical closed-form solutions, prices are functions of V, ϕ, α, and β, that is, the price of model i sold in country j is $P_{ij} = f(V_{ij}, \phi_j, \alpha_j, \beta_j)$, where V_{ij} is some function $g()$ that picks up consumers' valuations for different types of automobiles. We assume that consumers' valuations depend on model characteristics, their purchasing power, national tax level, whether the car is a domestic brand or not, and other unobservables. We also allow for the possibility of non-homothetic preferences that premium and basic models are valued differently in richer and poorer countries. Formally, we can write $V_{ij} = g(X_i, I_j, T_j, D_{ij}, S_i I_j, \varepsilon_{ij})$, where X_i represents a vector of model characteristics, I_j represents the purchasing power of consumers as given by their income, T_j represents the tax level, D_{ij} represents whether the model is a domestic brand, $S_i I_j$ represents an interaction between the premium segment and income which picks up non-homothetic preferences, and ε_{ij} represents unobservables. Putting everything together, we can write prices as:

$$P_{ij} = f(X_i, I_j, T_j, D_{ij}, S_i I_j, \phi_j, \alpha_j, \beta_j, \varepsilon_{ij})$$

Since the model parameters affect prices both directly and through the cutoff that determines the price discrimination regime, we need to include interactions between ϕ and the relative valuation parameters α and β. At the same time, since both α and β represent relative valuations and are very likely to be determined by the same factors and move together, we only need one variable to pick up their effects. We hence use a relative purchasing power variable (RP_j) between high-type and regular buyers (rich and poor) in country j to pick up the effects of both α and β. We can then write the empirical model to be estimated as:

$$P_{ij} = X_i + b_1 I_j + b_2 T_j + b_3 D_{ij} + b_4 S_i I_j + b_5 \mathrm{RP}_j + b_6 \phi_j + b_7 \phi_j \mathrm{RP}_j + \varepsilon_{ij}$$

We will estimate the parameters b of the model using data on the European automotive industry, collected from multiple sources. We assume the error term ε_{ij} is uncorrelated with the other explanatory variables, and the model-specific characteristics X_i will be picked up by model fixed effects. Of particular interest to us is to verify the model's predictions regarding the regime-dependent effects of the income inequality-related variables.

3.2 Data description

We use a fully balanced panel dataset comprising of 51 automobile models across 21 European countries, which gives a total of 1071 observations. The complete list of models and countries is presented in the "Appendix." The particular shape of this dataset differs from previous studies in its very essence—all previous studies focused either on cross-sectional data, or more traditional panels with models across time, in a given country. Our specification improves on the previous literature by allowing us to capture the effects of country-specific variables such as income and income inequalities which, according to our theoretical model, affect prices in a significant way.

Our dependent variable P_{ij} is the pretax manufacturer's suggested retail price (MSRP) in Euros for each model in each country of the sample on January 1, 2009. The price data were assembled from the European Commission report on car prices for the year 2009. The European Commission publishes this report[9] every year, as a measure to monitor competition, following numerous complaints from consumers unions about the industry standards, differences in prices, and anticompetitive practices that manufacturers and dealers engage in. We do not use after-tax prices, since taxes vary from country to country, and variations in final prices can either be the result of tax differences or the result of strategic pricing by manufacturers. We focus on strategic pricing and use tax-free prices, but do include tax levels in our estimations, as a control variable.

The explanatory variables consist of country-specific variables, which account for the cross-country heterogeneities. The most important variables for our study are the income-related variables, which are collected from UN sources and from Eurostat. These are the national per capita income, the relative purchasing power of rich to poor, and the share of the rich in the total population. The national per capita income will proxy for purchasing power and will account for I_j in our empirical model. To capture relative purchasing power and account for the variable RP, we use the ratio of the average income of the richest 10 percent to the average income of the poorest 10 percent as a proxy (RP10 ratio). Finally, to capture the proportion of rich-to-poor ϕ, we

9 http://ec.europa.eu/competition/sectors/motor_vehicles/prices/report.html.

Table 2 Regression results

Specification[a] Mean centering	(1) N/A	(2) Rich share	(3) RP10
Covariates			
Domestic	730.85*	730.85*	730.85*
Income	16.90***	16.90***	16.90***
Rich share	−309.27***	−309.28***	64.01***
RP10	−3817.03***	−53.63*	−3817.07***
Rich share × RP10	45.13***	45.13***	45.13***
Premium × income	−13.84**	−13.84**	−13.84**
Tax	−347.04	−347.04	−347.04
Constant	46,715.13***	20,924.64***	15,142.8***

Dependent variable—price in Euros (excluding taxes)
* Significant at 10 % level; ** Significant at 5 % level; *** Significant at 1 % level; $N = 1071$; $R^2 = 0.9660$
[a] The first specification includes all variables as is. The second specification centers the rich share variable around its mean, to estimate the unique effect of the RP10 ratio for average values of the rich share. The third specification centers the RP10 variable around its mean, to estimate the unique effect of the rich share for average values of RP10. Model fixed effects are included for all estimations. Clustered standard errors are used

use the share of population above 60 % of the median national equivalized income.[10] As explained earlier, we also have an interaction between the RP10 ratio and the rich share ϕ that will capture the regime-specific effects predicted by the theory.

Other explanatory variables that affect prices are a domestic brand dummy variable, coded with 1 if the model is a domestic brand, an interaction between income and whether the model belongs to the premium segment, and the tax level. The domestic brand dummy will capture preferences for domestic brands that could arguably influence prices. The interaction between income and the premium dummy will capture potential non-homothetic preferences. Finally, the tax variable will capture not only preferences for cars that are taxed lower, but also possible strategic pricing effects. It is possible that manufacturers have incentives to lower the price of heavily taxed automobiles. Tax levels for each individual model are computed from the before- and after-tax prices listed in the European Commission Report. A list with all relevant variables is included in the "Appendix".

3.3 Results

The results of the estimations are presented in Table 2. The differently numbered columns represent the results of three different specifications, which will be explained below. All specifications include car models fixed effects and panel robust (clustered) standard errors, robust to both heteroskedasticity and serial correlation.

[10] This is the threshold used by the EU to define the so-called in-work poverty line (Bardone and Guio 2005), which is a good approximation for the line that divides those in the basic car market from those in the premium market.

The first specification (1) includes the RP10 ratio, the rich share, and their interaction. Including an interaction of two continuous variables in the regression changes the way we interpret our coefficients. In particular, it becomes hard to isolate the unique effect of each individual variable. Both the rich share and the RP10 ratio are significant and negative, which is not what the model predicts. That is however, because of the interaction variable picking up a portion of the unique effect of each variable. Note that the effect of the rich share is less negative than the effect of the RP10 ratio, which hints at the fact that each variable has the expected sign for average values of the other variable. In the current estimation, the coefficients in front of the rich share and the RP10 ratio only reflect their unique effects when the other variable is zero.

To address this issue and verify that indeed the effects of these two variables are corresponding to the theoretical predictions, we ran two additional specifications. It is a common practice, when using continuous variable interactions, to recenter the variables in order to capture unique effects at different regimes. In specification (2), we recenter the rich share variable around its mean, which will allow us to capture the unique effect of the RP10 variable for medium levels of ϕ. In specification (3), we recenter the RP10 variable, in order to capture the unique effect of the rich share for medium values of RP10. These additional estimations clearly show that the theoretical predictions of the model are verified by data. Estimation (2) shows that the relative income of the rich to poor affects prices negatively when keeping the rich share fixed at the mean, which fits the theoretically predicted effect of β on prices, on any price discrimination regime. This is a direct price effect. There is arguably an additional cutoff effect of the RP10 ratio that comes through α, which is opposite in direction, but which seems to be dominated by the direct price effect. Estimation (3) fixes the RP10 ratio at its mean value and shows a positive effect of the rich share on prices, which is consistent with the effect of ϕ in the model. A larger proportion of the rich changes the price discrimination regime toward less price discrimination and higher overall prices. This is a cutoff effect. Note that less price discrimination actually means focusing on the high end of the market and ignoring the low end, thus raising all prices.

All remaining variables are significant and have the expected signs, except for the tax level. There does not seem to be any strategic pricing depending on the different tax rates in the member states. Prices are higher for domestic brands and in richer countries, which again is consistent with the theory. The interaction variable between the premium segment and income is negative, which suggests there might be non-homothetic preferences, where premium cars are less expensive in richer countries, and basic cars are less expensive in poorer countries.

Going further, we need to verify the remaining theoretical predictions. There are additional effects (both cutoff effects and direct price effects) of both α and β. These additional effects are theoretically different, depending on the values of ϕ. The theoretical model predicts that for small values of ϕ, prices are increasing in α (direct price effect) and also increasing in β (cutoff effect). Since the empirical variable RP10 is used as a proxy for both α and β, and their effects move in the same direction, we would expect prices to be negatively correlated with the RP10 ratio when the rich share takes small values. On the other hand, when the rich share is large, there is a negative effect of β on price; hence, we should observe a positive effect of the RP10 ratio when

Table 3 Regime-dependent effects

Specification[a] Rich share centering	(1) Mean − SD	(2) Mean + SD
RP10	−225.67***	118.40***

Dependent variable—price in Euros (excluding taxes)
* Significant at 10 % level; ** Significant at 5 % level; *** Significant at 1 % level; $N = 1071$; $R^2 = 0.9660$
[a] The first specification centers the rich share variable one standard deviation below its mean, to estimate the unique effect of the RP10 ratio for small values of the rich share. The second specification centers the RP10 variable one standard deviation above its mean, to estimate the unique effect of the rich share for large values of RP10. Model fixed effects are included for all estimations. Clustered standard errors are used

the rich share takes large values. To test these predictions, we use the same methodology as before, but we recenter the rich share variable to small and large values, respectively. For small values, we recenter it one standard deviation below the mean, and for large values, we recenter it one standard deviation above the mean. Table 3 presents the estimated coefficients of RP10 from these two additional specifications. In specification (1), the variable rich share is re-centered one standard deviation below its mean, while in specification (2) it is re-centered one standard deviation above its mean. For space considerations, we only report the coefficients of RP10. All other variables of interest have the same coefficients as before.

Both specifications yield highly significant coefficients that fit the theoretical predictions perfectly. For small shares of the rich, prices decrease with relative income, while for large shares of the rich, prices increase with relative income. We can therefore conclude that the empirical exercise provided strong support to the indirect price discrimination theory. Prices differ across borders not only because of direct international price discrimination, but also because within each country, indirect price discrimination mechanisms lead to different prices, depending on income distributions.

Another issue that we address is the role of exchange rates. Many pricing to market theories raised the point that if manufacturers desire a certain local currency price stability, they should price differently according to exchange rate volatilities on destination markets. We would therefore expect lower prices on markets with higher exchange rate volatility, to allow local dealers higher margins and the ability to keep prices from varying too much.

The role of exchange rates on car prices has been previously estimated to be relatively small. In particular, Goldberg and Verboven (2004) estimated only a reduction of 1–2 % in price differentials that resulted from the introduction of the Euro and elimination of exchange rates in the Euro zone. Nowadays, the main price differences remain between the Euro zone and the non-Eurozone countries, but we believe this is mostly due to large income differences rather than the presence of exchange rates. At the same time, our data do not contain a time dimension, and so it is hard to properly quantify the role of exchange rate fluctuations. Nevertheless, we try to test this hypothesis by using data on exchange rates from the previous year.

We collect data on the exchange rate between the local currency and the Euro, for every non-Eurozone country, on the first day of each month of the previous year. We then calculate the monthly fluctuations of the exchange rates, as the absolute

Table 4 Role of exchange rates

Sample[a]	Full sample	Full sample	Subsample
Domestic	301.63	92.12	−253.14
Income	−14.09***	−15.75***	−44.11
Rich share	183.10***	151.84**	838.20**
RP10	1104.09*	1609.82**	11,299.71*
Rich share × RP10	−15.03*	−22.04***	−142.01*
Tax	−589.31*	−113.02	1953.51**
Premium × income	−13.62**	−13.61**	−154.95***
Exchange rates	−1361.16***	−467.94***	−18.14
Euro zone	N/A	2093.37***	N/A
Constant	8098.91	9434.57*	−45,911.86
	$N = 1071$; $R^2 = 0.9719$	$N = 1071$; $R^2 = 0.9735$	$N = 408$; $R^2 = 0.9566$

Dependent variable—price in Euros (excluding taxes)
* Significant at 10 % level; ** Significant at 5 % level; *** Significant at 1 % level
[a] The first specification uses the entire sample, without a Euro zone dummy. The second specification also uses the entire sample, but adds the Euro zone dummy. The third specification restricts the sample to only non-Eurozone countries. Model fixed effects are included for all estimations. Clustered standard errors are used

percentage change from one month to the next. Finally, we compute and use the average monthly fluctuation, as a proxy for the true exchange rate volatility. The average exchange rate volatility over the entire non-Eurozone sample is 1.66 percentage points, with a standard deviation of 0.87. Naturally, exchange rate fluctuation is zero for all Eurozone countries, which are overall richer, and so the coefficient of the exchange rate fluctuations variable might not only pick up the unique effect of exchange rates, but also income effects. Introducing a Euro dummy significantly reduces the magnitude of this effect.

An important issue is that the exchange rate variable is a large source of multicollinearity. Multicollinearity is problematic from both a computational and statistical standpoints. It inflates the standard errors and also makes the coefficients extremely sensitive and hard to interpret. Sign flipping is a common problem, which we do observe. To partially correct the problem, we run an additional estimation on a subsample of only non-Eurozone countries. All the results are presented in Table 4. The first column presents the estimation with only the exchange rate variable added, the second column adds the Euro dummy, and the third column restricts the sample to only non-Eurozone countries.

The results show a negative role of exchange rate fluctuations, when the estimation is run for the entire sample, but it becomes insignificant when we restrict the sample to only the non-Eurozone countries. We cannot rule out multicollinearity, but we can safely say that the effect of exchange rates is either nonexistent or at best very small. The full sample estimate when the Euro dummy is included suggests a difference of about 468 Euros for every percentage point difference in exchange rate volatility. If we consider that the standard deviation of exchange rate fluctuations is of about 0.8 percentage points, and that the average car price is about 20,000 Euros with a standard deviation of around 13,000, the result is in line with previous estimates of 1–2 % of the price differentials stemming from exchange rates.

4 Conclusions

Price differences for identical automobiles across European Union member states have been going down during the last couple of decades. However, in spite of integration efforts, there still exist significant differences in pretax prices of up to 30 % across international borders. The latest wave of studies pointed at international price discrimination based on different price elasticities, the presence of a domestic brand bias, and possible collusion as the main causes of the persistent price volatility. We show that not only international price discrimination, but also domestic indirect price discrimination can result in international price differences. To that extent, differences in income inequalities across member states can result in different prices for automobiles across international borders. The empirical facts support the theoretical predictions. This is consistent with recent evidence that shows the largest part of the price variance still present is outside of the Euro zone, where member states are poorer and income heterogeneities are higher. At the same time, we cannot reject the role of exchange rates, but we find that only a very small part of the price variance can be attributed to this, which is in line with previous results in the literature.

While manufacturers and lobbying groups are still defending the exclusive dealership system, arguing that its only purpose is to ensure consumer satisfaction, questions need to be raised about the competitive implications of its existence. Restricting car sales through only exclusive dealers prevents free arbitrage opportunities and will continue to keep prices from fully converging, in spite of integration efforts. We believe more quantitative research should be done on the competitive implications of having exclusive dealership contracts in place, and the European Commission should take a larger role in making dealership and manufacturer data available for study.

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5 Appendix

See Tables 5, 6, and 7.

Table 5 Relevant empirical variables

Domestic	Domestic brand bias dummy (equal to 1 if model is native to destination country)
Income	National per capita income (in thousands of dollars)
RP10	The ratio of the income of the richest 10 % to the income of the poorest 10 %
Rich share	The share of population above 60 % of the median equivalized income
RP10 × rich share	Interaction between the RP10 ratio and the rich share
Tax	Tax level for specific model
Premium × income	Interaction between income and a premium dummy
Exchange rate fluctuations	Average monthly change in the exchange rate during the previous year
Euro zone	dummy equal to 1 if country belongs in the Euro zone

Table 6 List of car models included in the sample

Alfa Romeo 147	BMW 730d	Kia Ceed	Opel Corsa	Seat Ibiza	VW Polo
Audi A3	BMW X5	Maza 2	Opel Astra	Skoda Fabia	VW Golf
Audi A4	Citroen C4	Mazda 3	Opel Zafira	Skoda Roomster	Volvo S40
Audi A6	Fiat 500	Mercedes C220	Peugeot 107	Subaru Forester	Volvo XC90
Audi A8	Fiat Panda	Mercedes E220	Peugeot 308	Suzuki Swift	
Mini Cooper	Fiat Grande Punto	Mercedes S350	Peugeot 4007	Suzuki Grand Vitara	
BMW 120d	Fiat Bravo	Nissan Micra	Renault Clio	Toyota Yaris	
BMW 320d	Honda Civic	Nissan Note	Renault Laguna	Toyota Auris	
BMW 523i	Honda Accord	Nissan Qashqai	Saab 9-3	Toyota Avensis	

Table 7 List of countries included in the sample

Austria	Denmark	Hungary	Netherlands	Slovenia	The United Kingdom
Belgium	Finland	Ireland	Poland	Slovakia	
Bulgaria	France	Italy	Portugal	Spain	
Czech Republic	Germany	Luxembourg	Romania	Sweden	

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