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Does marketing widen borders? Cross-country price dispersion in the European car market

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Abstract

We study cross-country price differences in the European market for new passenger cars based on detailed pricing and technical data. Car prices in Europe converged until the year 2003, but not thereafter. Within the EU 15 countries the price range of the median model in 2004 was close to 20 percent. We document a source of international price differentiation, which is not related to distribution and border costs, but instead systematically linked to product features. Price dispersion increases with the market segment and varies significantly across models. Marketing appears to position identical goods differently in each country, for example by feature bundles tailored to local consumer preferences. Both the convergence before the actual reduction of barriers to arbitrage and the systematic international price differentiation by product feature point to active pricing-to-market strategies that treat countries as marketing regions.

Keywords: arbitrage, European car market, international price dispersion, law of one price, market segmentation

JEL Codes: F15, F31, L11, L62, D22

Non-technical Summary

Under fairly general conditions a firm can increase its revenue by tailoring its price to its customers' willingness to pay. A crude way of tailoring a price is charging different prices by country. But whereas firms have a clear incentive to differentiate prices across countries, their ability to do so is limited by cross-border arbitrage, especially if transaction costs and regulatory barriers are low. The member countries of the European Union (EU) share an integrated common market, featuring a tight infrastructure, a common regulatory framework, deep trade relations, an active competition policy, and in a part of the region even a common currency. Therefore one would expect arbitrage to wipe out any major price difference between EU member countries.

This working paper studies if and why prices differ across countries in such an integrated market setting. The focus is on new passenger cars, for three reasons. First, a car is the most significant purchase of a tradeable good that households make, and therefore the potential gains from buying abroad are large compared to the effort of comparing prices internationally. Second, cars are branded items produced in very few locations that are relatively easy to compare internationally. Third, most new cars in Europe are built-to-order, muting the potential effect of local inventory fluctuations. The underlying data is an unbalanced panel of the list prices of the most popular car models within each segment in each EU member state. Prices are sampled twice per year from 1993 until 2006, and once per year from 2007 until 2011. Starting in the year 2000, detailed technical information is also available.

We find that car prices are widely dispersed, even within the single market of the EU. Price differences across countries vary by model. In the year 2004, when prices were least dispersed, the price range of the median model was close to 20 percent even within the EU15 countries, and considerably higher in other years.

Car prices in Europe converged until the year 2003. Since then car prices have shown no sign of further convergence. During the financial crisis, dispersion even jumped up again. Prices appear to have converged in anticipation of the regulatory push towards more market integration between 2002 and 2005, rather than adjusting to it thereafter. Within the euro area prices are less dispersed than within the EU overall. However the entire convergence effect occurred at the time of joining – there is no evidence of further convergence within the euro area later on. All this suggests a proactive price adjustment by manufacturers, well before noteworthy international arbitrage could kick in.

This paper shows that international price differences are anything but random; they are systematic. Car features are priced very heterogeneously in Europe. These price differences are grounded in the heterogeneity of consumer preferences and of regulation within the EU. Panel regressions uncover international price differentiation based on, e.g., regulatory, market and climatic differences.

Price differentiation does not stop at country differences that are exogenous to manufacturers. We find evidence that the marketing of identical products differs by country. Heterogeneous brand positioning is reflected in a differential pricing of home brands across countries. Centrally positioned brands display lower price levels but wider price dispersion across countries. Even the market segment (e.g., small cars, luxury cars, etc.) matters: Price dispersion increases with the market segment. Higher segments might have a less elastic demand, and we conjecture that the higher complexity of a car in upper segments is one reason for this. The higher complexity permits the marketing of a multiplicity of different versions of a mechanically identical car model. Marketing appears to position identical goods differently in each country, for example by feature bundles tailored to local consumer preferences.

Both the convergence prior to the actual reduction of barriers to arbitrage, and the systematic prices differences by product feature suggest that manufacturers treat countries as marketing regions. Today segmentation along country-specific marketing appears to dominate segmentation along regulatory barriers. In other words, the EU is integrated from a regulatory point of view, but consists of many segmented marketing regions. If the elimination of border effects was desired, competition policy would have to limit the scope for differential marketing, for example by requiring an unbundling of non-essential car components and an offering of an identical menu of options in all countries.

Heterogeneous marketing does not widen borders, but mirrors spatial diversity. Even integrated markets might contain regional differences in preferences. Often regions of common preferences coincide with countries. This renders countries natural marketing regions, even within an integrated market.

1 Introduction

Pricing-to-market (PTM), the practice of differentiating the retail or wholesale price of a good across markets, is an established fact (e.g. Alessandria and Kaboski, 2011; Atkeson and Burstein, 2008; Berman, Mayer, and Martin, 2012; Burstein and Gopinath, 2014; Gron and Swenson, 1996; Simonovska, 2015; Strasser, 2013). Much less is known about the exact mechanisms through which PTM is achieved in practice. For example, a recent report of the Canada Senate on the persistent price gap with the U.S. with a special attention to car prices noted that after hearing extensive expert testimony and taking into account differences in regulation and taxation the committee "cannot offer an explanation as definitive as it would have liked for the price discrepancies for products between Canada and the United States" (Day, Smith, Neufeld, and Gerstein, 2013, p. vi). Price differentials between countries are often attributed to the structure of the economy, e.g. to differential distribution costs (Burstein, Neves, and Rebelo, 2003; Corsetti and Dedola, 2005) or border costs (Engel and Rogers, 1996). But in advanced economies transaction and travel costs are low, and governments routinely promote competition through trade agreements and regulatory measures, so one would expect arbitrage to constrain the ability of firms to price to market. The persistence of PTM in these countries remains therefore something of a puzzle.

We examine the practice of PTM in what is perhaps the most studied example in the literature: the European car market (e.g. Auer, 2013; Gil-Pareja, 2003; Goldberg and Verboven, 2001, 2005; Mertens and Ginsburgh, 1985; Verboven, 1996a,b). Countries of the European Union (EU) are natural candidates for any discussion of market integration. They share a tightly integrated transportation infrastructure, a common regulatory framework, and deep trade relations. Not least, most of them either use a common currency (the Euro) or currencies which are credibly pegged to it.

The car is the most significant purchase of a tradeable good that households make. The car market could be a highly visible indicator of European market integration and is as such the focus of intense scrutiny. For this reason, and despite exempting the passenger car market from the unrestricted competition article of the EU treaty, the European Commission (EC) aims to increase market integration within Europe: car warranties must be respected across the EU; cross-border car buyers are exempt from taxes and fees in the country of purchase; car registration documents are valid EU-wide; even cross-border purchases to and from the British Isles are accommodated by requiring manufacturers to deliver upon request right-hand drive steering cars to dealers on the Continent (European Commission, 2002; European Commission DG-COMP, 2002). All sources of market segmentation that Goldberg and Verboven (2004) list as explanations for price differentials in Europe have more or less vanished since then.[1] In this paper we trace some of these price differences to price differentiation by marketing: versioning an otherwise homogeneous product across countries. In particular, country-specific versions of a car can be created by changing the menu of included car features in each country.

Comparing car prices across countries is not a trivial exercise, neither for consumers nor for economists. A typical car buyer in Europe is presented with a menu of standard and optional features and auxiliary services which varies by country, rendering a direct "apple-to-apple" comparison difficult. A basic and necessary contribution of this paper is the creation of a data set which allows conducting price comparisons of identical products. For this purpose we collect and merge data on prices, technical characteristics, and tax regimes, so that we are certain that the pre-tax price of, for example, a particular Ford Focus purchased by a German buyer from a French dealership is comparable to the pre-tax price that same consumer would have paid in Germany.

Based on the new dataset, the second contribution of this paper is to show that PTM in Europe is pervasive throughout the sample period (1993–2011), with little evidence of absolute convergence since the year 2004. This is true across the euro area as well as across the entire EU. It is a surprising finding given the decline in price dispersion in the 1990s, as already described in earlier literature. It is even more surprising given the vigorous efforts by the European Commission to increase competition in the new car market and to reduce the obstacles to arbitrage.

Our data consists of prices, P_t^{mc}, sampled for car model m in country c at time t. We define the real exchange rate for a given model m between a given country c and our base country, the Netherlands, as the logarithmic difference between the pre-tax, euro-denominated prices. Denoting the natural logarithm by lowercase letters, the model-specific real exchange rate is given by $r_t^{mc} = p_t^{mc} - p_t^{m,NL}$. Figure 1 presents histograms of this real exchange rate for two sets of years. Under the law of one price, these distributions would be concentrated tightly around zero. We see instead that real exchange rates are widely spread out, with no sign of (absolute) convergence to zero over time. If anything, real exchange rates diverge slightly from 2003 to 2011.[2]

[1] We discuss recent regulatory developments in the EU car market in detail in the Online Appendix C.

[2] It is important to distinguish between absolute and conditional convergence of prices across countries. While

[Figure 1 about here.]

What can explain these features of the data? Our third contribution is identifying mechanisms which allow PTM to take place. We show not only how prominently price differences reflect country differences but also how these price differences are sustained despite integrated markets. With respect to the former we strengthen earlier findings that manufacturers' prices take advantage of existing market segmentation in Europe. Thus prices respond to differences in, for example, income and tax rates across countries. With respect to the later we show that car manufacturers seem to differentiate identical products by differential bundling of their products across markets. Importantly, the menu of choices for the same model can and does vary across countries. We find that the bundling of features systematically affects the price of a car and thus model-specific real exchange rates. Specifically, if air conditioning (AC) is included in the car's price as standard, it is on average more expensive than air-conditioned cars where AC is sold as an option in the North; but not so in the South. Because we compare the prices of identical cars, all with AC, this amounts to price discrimination across countries.

Due to its visibility and the regulatory attention it receives, the market for European new passenger cars has been the subject of many studies (Ginsburgh and Vanhamme, 1989; Kirman and Schueller, 1990; Mertens, 1990; Mertens and Ginsburgh, 1985). Many of these studies focus on whether price differentials between EU members have declined since the start of the common market in 1993. In the early 1990s the price differences were still very large (Verboven, 1996a). In response to this apparent lack of market integration, the European Commission in 1993 started collecting pre- and post-tax prices for about 75 car models at least once a year. Beginning with the report of Degryse and Verboven (2000) to the Competition Directorate-General of the EC in 2000, this data set (henceforth "EC data set") forms the basis for most subsequent analyses of the European car market.

Degryse and Verboven (2000) base their analysis on pre-tax list prices for the years 1993–2000.[3] There is no evidence of diminishing price differentials across countries. Also, price variation across countries differs substantially from model to model. Except for luxury cars price variation appears to be model idiosyncratic. As expected, high tax countries have a com-

there is no evidence of absolute convergence in our data, conditional convergence to a country-specific mean is rapid (Dvir and Strasser, 2014) and faster in the period 2003-2011 than in earlier estimates (Goldberg and Verboven, 2001, 2005). But we see no evidence of convergence towards a single European price for passenger cars after 2003, contrary to recent EU reports (e.g. European Commission, 2009, p.6).

[3]The contemporaneous paper by Gaulier and Haller (2000) uses the same EC data set for the period 1993-1999 to construct aggregate price indices. Doing so, most of the panel information is lost. They document lower pre-tax prices in high tax countries, as do Kirman and Schueller (1990).

paratively low pre-tax price. A special survey allows Degryse and Verboven (2000) to adjust for differences in customer discounts and dealer margins across countries, but these differences are small and have therefore no effect on the results. More than half of the price differential for individual car models remains unexplained by their explanatory variables (taxes, exchange rates, margins, right-hand drive). We take Degryse and Verboven (2000)'s analysis one step further and explore the impact of the car specification on the price differentials. We show that the differences in price dispersion are by no means random. They are systematically linked to car features or marketing.

The papers that follow the seminal studies describe a car market characterized by substantial price dispersion, though declining over time (Gil-Pareja and Sosvilla-Rivero, 2008; Goldberg and Verboven, 2004, 2005), and by widespread PTM (Gil-Pareja, 2003). Regarding the sources of price dispersion, Goldberg and Verboven (2001) conclude that cost differences across countries account for a higher fraction of price dispersion than brand-specific markups. Lutz (2004) also finds evidence of variable markups, but concludes that barriers to arbitrage between markets play the bigger role. The full European car price data set itself, which motivated the regulatory action, has not been updated since 2003.[4] Accordingly, the success of EU regulatory policy in the car market after 2003 has not been quantitatively examined outside of the EC. In this paper we do so. We build a data set with the same structure as the commonly used pre-2003 data, covering all recent survey years. By extending the panel over time, we are also able to study the effect of the euro on price dispersion.

Substantial price dispersion within and across countries is extremely common for products other than cars as well. It is often too large to fit common explanations, such as the cost of crossing a border or the differences in the cost of non-traded goods. In fact, tariffs and regulatory import hurdles have fallen to historic lows across the industrialized world as well as in many developing countries, but price dispersion in traded goods does not seem to have become smaller. Also, price dispersion among US cities is even larger for traded goods than for non-traded goods (Engel and Rogers, 2001). Using micro data, Crucini and Shintani (2008) find no meaningful difference in price dispersion between traded and non-traded goods. At the same time, cross-border arbitrage in some markets can be substantial (Asplund, Friberg, and Wilander, 2007), indicating that there is no lack of potential arbitrageurs. Currently there is no

[4] Most later studies of the European car market work with variants of the pre-2003 data. An exception are Gil-Pareja and Sosvilla-Rivero (2012), who select 45 models and 15 countries from an updated EC data set. Applying various panel unit roots test to the 1993–2008 data gives them only weak evidence of price convergence.

satisfactory explanation as to why price differences across countries persist.

These deviations from LOP have been the subject of intense debate in the international finance literature. This literature has, since the seminal paper by Engel and Rogers (1996), increasingly used micro data to examine cross-country price dispersion. Whereas for commodities LOP holds (Baffes, 1991), already within a global retailer such as IKEA deviations from LOP are large and cannot be explained with distribution costs or taxes (Baxter and Landry, 2012; Haskel and Wolf, 2001; Hassink and Schettkat, 2003). The IKEA results are based on prices quoted in different currencies. Within the euro area online stores of two large fashion chains, as well as of Apple and IKEA, however, seem to obey to the law of one price in more recent years (Cavallo, Neiman, and Rigobon, 2012).

Our paper revisits this debate but examines a very different market. Instead of small and (after sample selection) easy-to-compare household items,[5] we compare large ticket items, namely cars, which are the largest household expenditure item after buying a house. Compared to household items, cars are a very heterogeneous good, but with well-documented differences, which we exploit in this paper. Furthermore, we do not rely on online prices, but dealership prices for made-to-order cars.[6] Finally, the market we study has been explicitly deregulated to allow for cross-border purchases. That is not the case with online purchases for example, where cross-border purchases are often blocked.

We proceed as follows. The next section describes our data in detail. Section 3 examines the development of price dispersion in Europe over time. Section 4 shows that country-specific preferences help explain this persistence of international price differences. Section 5 studies the effect of country-specific policies and shocks, in particular the financial crisis. We discuss policy implications of our findings and conclude in Section 6.

[5]Broda and Weinstein (2008) use Universal Product Codes (UPC) to ensure that they are comparing identical products, and find no additional price dispersion across the border. In contrast, Gopinath, Gourinchas, Hsieh, and Li (2011), also using UPC codes, find a considerable price gap between identical products in stores belonging to the same retail chain but located across the US-Canada border. This price gap is almost entirely driven by variation in wholesale costs borne by the retailer and consistent with full segmentation of markets. However, the essence of a UPC bar code is that the product is identical across countries. In this paper we focus instead on differentiation of the standard bundles of product features, which turns out to be an important avenue for manufacturers of implementing PTM and presumably collecting monopoly rents.

[6]Online distribution of new cars has been extremely uncommon during the sample period. Online car brokers started entering the, for example, German market in 2005, but as of 2011 their market share remained negligible (Dudenhöffer and Neuberger, 2011).

2 Data and Definitions

In this section we describe the key data series, introduce two definitions of a car model, and provide an overview of the data.

2.1 The Data

We collect data on car prices, technical specifications, taxation, plant locations, brand perception, and country properties.[7] The data sources and data cleaning procedure are described in more detail in Appendix A.

2.1.1 Car Prices

Our car price data come from the European Commission's Directorate General for Competition.[8] This data set (henceforth "EC data set") was collected and distributed from 1993 until 2011 by the EC as a service to European consumers who wish to compare prices across countries. The data covers car models at the country level. Its scope are all EU member countries at the respective time, which translates into up to 27 countries. Until 2006 inclusive, the EC published semi-annual reports for May and November of each year. In 2007, the EC switched to annual reporting (for May of 2007 and then for January of 2008 and later years). Publication of the report ended in 2011.[9] Our data set contains the list prices of new cars, with and without tax, as well as information on standard features and the availability and pricing of several optional features.

New cars in Europe are usually custom ordered at the dealership, where the buyer can choose from a menu of available features such as engine type, body color, air conditioning (AC), and an

[7]Data on population and on GDP per capita at constant international prices are from Eurostat, the statistical office of the EU, and available at `ec.europa.eu/eurostat`. The indirect taxes on petrol paid at the pump by consumers are taken from the EC's Oil Bulletin, available at `ec.europa.eu/energy/observatory/oil/bulletin_en.htm`.

[8]The raw data is publicly available for download at `http://ec.europa.eu/competition/sectors/motor_vehicles/prices/report.html`. Appendix A.1 describes the process we employed to standardize and thoroughly clean the data in detail.

[9]The EC's website offers the following reasoning for ending the survey: "Between 1993 and 2011, the Commission has published annually the [...] Car Price Report. This report has been discontinued. When the report was launched, there were major car price differences among Member States, and it was much more difficult for consumers to compare prices across borders. Since then, the situation has improved greatly, in part due to enforcement action by the Commission, and also thanks to the increased availability of price information on the internet. This means there is no longer a need for the Commission to duplicate this information in the Car Price Report." (European Commission, 2013) The findings of this paper cast some doubt on this assessment of price differences in Europe.

anti-lock breaking system (ABS). List prices for the basic car model and for all available options are determined by the manufacturer, and updated periodically. The dealer usually stocks only a small number of new cars for immediate sale. Normally, customers need to wait weeks or months while the car which exactly fits their specifications is assembled and delivered to the dealership. Discounts and financing packages are typically determined by the manufacturer as well and apply throughout the country.[10] Price competition among dealers is quite limited as a result.

Given the limited scope for comparison shopping within countries, European competition authorities are keen to encourage cross-border shopping. Our data set was assembled by the EC for exactly that purpose.[11]

2.1.2 Car Specifications

We obtain technical data on all car models sold in the United Kingdom (UK) from the website of the UK government's Royal Certification Agency (RCA). Every car model sold in Britain must undergo testing and certification by this agency, since each car's official emissions and fuel consumption data are determined in this way.[12] The RCA dataset adds information on fuel consumption and emissions, augments the information on engine size and power in the EC data, and serves as a cross-check. We are able to match almost 90% of the models in our price data with the models in the RCA data set.[13]

[10]Dealership discounts in Europe for newly built-to-order cars are small, rarely exceeding 10% (Degryse and Verboven, 2000). Based on undercover shoppers and manufacturer responses Degryse and Verboven (2000, p. 112) conclude that "the average discounts do not differ substantially across countries," and thus have a negligible effect on real exchange rates. Some dealers offer "near new" cars, usually last year's models or cars ordered but for any reason not claimed. This is a different market altogether: the cars are sold as-is, and are already fully licensed. This market features much more robust price competition, with significant differences from list prices, similarly to dealer practices in the United States. Supply in this market, however, is limited; it is essentially a clearance market.

[11]The EC maintains a website to educate European consumers about their rights to shop for cars anywhere in the EU: `http://europa.eu/youreurope/citizens/vehicles/index_en.htm`

[12]The agency's website `http://carfueldata.direct.gov.uk` provides the year-by-year results of these tests. Manufacturers treat Europe as a single market in terms of their choice of models, i.e., a particular model m sold in the UK will be identical to the same model sold in Bulgaria. We therefore apply the UK technical data to car models in all countries.

[13]We match the cars based on time, brand, model name, engine capacity, engine power, fuel type and transmission, depending on which of these features were noted in the price data. Manual and automatic cars are tested (and thus matched) separately, because they differ in their emission and fuel consumption values. The brand Lancia was not sold in the UK during the sample period, therefore it cannot be matched with technical data and we exclude it from our analysis. Appendix A.2 describes the matching procedure in detail.

2.1.3 Taxation

Cars sales in Europe are subject to value added tax (VAT), whose rate differs by country and can change over time. Some countries tax new cars additionally at registration based on technical properties such as engine size, engine power, emissions (carbon dioxide CO_2, hydrocarbons HC, nitrate oxides NO_x, particles), or the overall EU emission standard. Less common are taxes based on fuel consumption, weight, or length of the car.

Cross-border car purchases are conducted on a pre-tax basis. We calculate effective registration tax rates from the pre- and after-tax prices recorded in the EC dataset. We double-check their plausibility using a taxation manual published by PricewaterhouseCoopers (2011).

There are large, sometimes very large, differences in effective tax rates across countries. On the lower end of the spectrum, the effective tax rate can in extreme cases be smaller than the VAT because of tax incentives. On the other end of the spectrum, some high-powered cars in Denmark are subject to an effective tax rate of more than 240%. The total tax can reach more than €150000 for high-end Audi and Mercedes models in Denmark in some years. In 2011, the median effective tax rate across all models as a percentage of the pre-tax price was lowest in Luxemburg (15%) and Germany (19%) and highest Denmark (186%) followed by Finland and Malta with about 50%. While these differences should not directly play a role in the decision to purchase cross-border, they may play a role in the manufacturer's pricing decisions and therefore may contribute to price discrimination.

2.1.4 Assembly Plant Locations

Price differences across countries may arise simply from transportation costs between countries. Whereas domestic delivery cost are supposedly accounted for in the EC data set, we account for cross-border shipment cost by the distance from the factory. We collect annual data on the European assembly locations by car model, starting in the year 2000, from the industry publication "Automotive News Europe."[14]

Due to large economies of scale, a given car model is produced in very few locations. At least 75% of the observations are cars produced in a single location for the entire European market. Notable exceptions are the high volume models Opel Astra and Volkswagen Golf with

[14] The data is available at the website `europe.autonews.com`, which requires a subscription for some years. We have data for 2003–2008, and for 2012. We interpolate and extrapolate the missing years to cover the entire period 2000–2011. In this way we are able to determine the assembly location of more than 98% of the observations during these years. Assembly locations for a given model barely change over time.

up to four production locations in some years. Only 8% of observations are cars produced simultaneously both within and outside the euro area in the boundaries as of the respective sampling date. Keeping these exceptions in mind it is fair to view car models as generally produced in one common location for all of Europe, and thus to attribute most price dispersion of an identical car model to regional segmentation. In popular datasets of retail goods the assumption of a common production location is difficult to establish, because these goods are often produced locally or in multiple locations. An exception in the literature are Burstein and Jaimovich (2012), who control for the country of origin of the product. More similar to our data, Fitzgerald and Haller (2014) sample prices from individual Irish manufacturing plants. Unlike them we assign car models to plants indirectly, based on industry reports, exploiting the relatively small number of makes and manufacturing plants in the car industry.

For each model-country pair we calculate the distance from the nearest assembly plant to the country's capital city, using exact coordinates and applying the great circle formula. For models imported from Japan, South Korea, or the USA we calculate the distance from the European port of entry where we know it. In cases where port of entry information is unavailable we assume import through the port of Rotterdam. We choose Rotterdam, because it is located in our base country, and close to and between the main European ports for car handling, namely Antwerp and Zeebrugge in Belgium and Bremerhaven and Emden in Germany.

2.1.5 Brand Centrality

To control for the competitive position of a brand, we collect data from an internet search engine. Google Insights reports which search terms are most commonly entered jointly. In particular, we observe how often two brands are searched for together. Based on this information we calculate the centrality of each brand in a given country, relative to all other brands.[15] We interpret this measure as follows: if a brand is relatively central, it is seen by potential car buyers in that country as relatively substitutable to other brands. Therefore the brand manufacturer's ability to demand a high price will be limited. The centrality measure varies by country and brand. It ranges from zero (about 15% of all brand-country pairs) to slightly more than 0.5 for Toyota in Malta. Overall, Toyota is the most central brand, with a centrality average of 0.36 across all countries, followed by Nissan and Citroen. The most idiosyncratic brands are MG Rover and Land Rover, with a centrality average close to zero, followed by Mini and Saab.

[15] We describe the data collection and the calculation of the eigenvector centrality measure in more detail in Online Appendix A.3.

2.2 Model Definition

From the year 2000 onwards we are able distinguish models based on very detailed information, namely model name, an automatic gearbox indicator, engine size, engine power, fuel type, number of gears, euronorm, number of doors and a right-hand drive indicator. We refer to this as the *narrow* model definition. For comparison with other studies and with periods before the year 2000 we also use a coarser distinction between models, based only on model name and an automatic gearbox indicator, excluding any right-hand drive observations. We refer to this as the *broad* model definition. When comparing our post-2000 data with data for earlier periods, we break all series after December 1999, i.e. we start with new models in January 2000, in order to rule out that subtle differences in model definitions between the two subsamples affect our results.

We subject the data to a rigourous cleaning and plausibility check. We exclude from our analysis a car (observation) if its price or key technical information after the year 2000 is missing, or if its recorded specification is uncommon and its existence unverifiable. We further exclude observations which are inconsistent across countries or across car properties, unless the correct value is obvious. The resulting dataset covers Europe's most popular models within each segment, sold under 27 different brands, and comprising 204 models in an unbalanced panel.[16]

2.3 Data Summary

Our analysis is based on pre-tax prices, because European buyers of new cars pay registration taxes in their country of residence, not in the country in which they buy the car. We define the price P_t^{mc} as the pre-tax price in country c in period t of this fully-equipped car model m measured in euros. In the following we define our base country and clarify the difference between the heterogeneity of products and the violation of LOP in our data.

2.3.1 Base Country

[Table 1 about here.]

The left four columns of Table 1 show that the Netherlands, Spain and Belgium have the most representative pre-tax car prices in Europe. Prices in Denmark and the Poland tend to be

[16] See Online Appendix A.4 for more summary statistics.

in the extremes. Interestingly, despite its central location and infrastructure, the new car prices in Germany are far from the European average. We choose the Netherlands as base country because of its intermediate car price level as well as its central location. Our choice is the same as the one of Goldberg and Verboven (2004, p.503).

2.3.2 Decomposition into Model, Country, and Time Effects

The dataset covers a very diverse set of cars. It includes Kias as well as BMWs, small cars as well as luxury cars. The first row of Table 2 shows the relative unexplained variation in an ordinary least-squares regression of pre-tax prices, P_t^{mc}, on model and time dummy variables and their interactions. More than 98% of the variation in pre-tax prices is explained by differences between models and common time variation. Any remaining variation must be either idiosyncratic or due to an interaction with country effects. Unsurprisingly, after-tax prices have a larger country component – more than 35 times larger than pre-tax prices – which is due to extremely large differences in new car taxation in Europe. A tighter time window reduces this variation a bit. Throughout this paper the focus rests on the residual from this regression, ρ_t^{mc}, for pre-tax prices.

[Table 2 about here.]

The second row of this table decomposes the residual ρ_t^{mc}, the non-model-specific variation, into cross-country dispersion and time variation by applying the conditional variance identity. Under the narrow model definition in column (1), on average 80% of the variation at the model level is due to the dispersion of country long-run mean prices, rendering the other component, the average country-specific time variation $E[Var(\rho_t^{mc}|cm)|m]$, almost negligible. Just as Crucini and Telmer (2012) and Crucini and Yilmazkuday (2014) observe in a sample of global consumer goods prices, the idiosyncratic variation at the goods level, i.e. in our context the variation across countries for a given car model, dominates the (country-specific) time variation. Several papers focussing on relative purchasing power parity show that this common time variation traces the nominal exchange rate closely, for example Burstein and Jaimovich (2012) and Gopinath et al. (2011) based on retail chain scanner data. As just noted, however, this is the smaller component of international price dispersion; the country-level differences dominate.

Rows 3 to 6 of Table 2 drive deeper into the causes of this price variation. They reaffirm the relatively minor role of country-specific time trends, which might be due to idiosyncratic trends in e.g. labor or distribution costs, in explaining price dispersion. Country (level) effects explain 20% (row 3). Country-specific time effects common to all models add only 14% explanatory power on top of country effects (row 4). This is dwarfed by the additional 62% of the variation in ρ_t^{mc} explained by country-model effects (row 5). Overall, of the variation in this residual 87% under the narrow definition and 73% under the broad definition can be explained by country effects and their pairwise interaction with model and time effects. The remaining variation is due to unmodelled idiosyncratic country-model-time effects. It reflects, for example, a specific model being cheaper in a specific country for only one specific period, an effect captured neither by the (time) average price of this model in this country, nor by the (cross-country) average price of this model in this period. The more precise the model is defined, the smaller is the unexplained variation after accounting for country effects, which is also evident from the comparison of columns (1) and (2) in row 7. Small differences in the car specifications across countries inflate the unexplained variation. For this reason a broader model definition exaggerates the idiosyncratic component.

Column (4) of Table 2 illustrates the very different properties of after-tax prices. Not only the variation of ρ_t^{mc} is more than 35 times, but even the variation of ε_t^{mc} is almost 5 times larger for after-tax prices than for pre-tax prices. The examples given in the previous section have already shown that this taxation can be very idiosyncratic. We see here again that it is specific to a very small set of models for a limited period of time, and is therefore not picked up by the any of the controls. It confirms the irrelevance of the after-tax price for arbitrage and thus for international car price comparisons, and supports the choice of pre-tax prices as the price for which LOP might be expected to hold.

The mere magnitude of country effects, in particular country-model effects, warrants a detailed investigation of its determinants. Shedding some light on why international price *levels* differ permanently requires a dataset that is sufficiently rich along three dimensions: country, time, and product. Our dataset strikes the necessary balance. First, it covers multiple countries, which allows us to extract a relationship between country properties and the price level. Second, it covers multiple years, which enables us to rule out country-year idiosyncracies. Third, it covers a multitude of car models, which permits identifying car properties that support cross-country price differentiation. A novelty of our paper is studying the interplay of cross-country and cross-product differences

3 Price Dispersion

In this section we document periods of price convergence and divergence, and the role of the euro. We identify segments of the car market that are particularly prone to price dispersion, and events that strongly affected price dispersion.

Several regulations have been enacted to facilitate cross border car shopping, covering taxation, warranty, insurance, and registration. Notable regulations include the introduction of EU-wide two-year warranty regardless of country of purchase (European Commission, 1999), and of EU-wide car registration documents (European Commission, 2004). A series of rules contained in the Block Exemption Regulation of 2002 (European Commission, 2002) regulate agreements between manufacturers and dealerships with the express purpose of fostering more competition. For example: manufacturers may select which dealers would be allowed to sell their models, but cannot prevent these dealers from selling to any customer, regardless of residence; dealers on the Continent, where driving is on the right-hand side of the road, cannot be prohibited from ordering cars meant for left-hand-side countries such as the U.K and Ireland; manufacturers cannot require that maintenance be performed only at particular dealerships to maintain warranty; and so on. Note, however, that there is no requirement that manufacturers offer consumers the same choices in all European countries. Manufacturers can tailor the menu of choices to car buyers in different countries.

3.1 Time Trends in Price Dispersion

We look first at the evolution of price dispersion over time in the entire European car market. Model price dispersion, Ξ_t^m, is the standard deviation of log prices p_t^{mc} for a given model m at a given time t across countries c, i.e.

$$\Xi_t^m = 100 \times Std(p_t^{mc}|mt). \tag{1}$$

We use only Ξ_t^m values based on at least three countries, but a tighter criterion would not change the results.

3.1.1 A History of Car Price Dispersion in Europe

The dispersion of car prices varies widely across models and over time.

[Figure 2 about here.]

Figure 2 shows the range of within-model price dispersion across EU15 countries for each survey period. Because this graph includes pre-2000 years, we use the broad model definition here. For the years 2000-2011 the graph under the narrow model definition looks similar. Focussing on the EU15 subsample ensures that none of the time variation after the mid-1990s is due to the expansion of the set of countries over which the dispersion is calculated. The boxes represent the 25$^{\text{th}}$ to 75$^{\text{th}}$ percentile range, with the horizontal line marking the median. At any point in time, the price-dispersion differs a lot between models. Compared to this large variation of dispersion across models, the time variation during these 19 years is rather small.

Two crises, one at the beginning and one at the end of the sample, dominate the graph. The price divergence episode at the beginning of the sample, from 1993 to 1995, coincides with the ECU crisis ("pound crisis") around August 1993. In the wake of this crisis, the currencies of Italy and UK were devalued and their currency band widened. Given sticky nominal prices this adjustment of nominal exchange rates entailed an immediate price divergence. Interestingly, this increased price dispersion was not arbitraged away immediately, but persisted for several years. The jump in price dispersion near the end of the sample, from (January) 2008 to (January) 2009, is due to the more recent financial crisis. Common to both crisis episodes is that the elevated dispersion dissipates only slowly, despite considerable regulatory effort in the past decade to remove obstacles to cross-country arbitrage. The years 2010 and 2011 show a slow convergence toward the pre-2008 situation, but in 2011 the average dispersion was still higher than in 2008.

With the exception of a few outliers in 2009, all models were affected similarly in both crises. Specifically, since models differ in their dispersion in 2008 by about the same as in 2009, the overall jump in dispersion can be largely assigned to country, as opposed to model factors. This may be due to the heterogeneous performance of European economies during the recession, as well as to large exchange rate movements of some European currencies vis-à-vis the euro. Also, "cash for clunkers" programs may have temporarily decoupled car prices from the prices in countries without such programs.

The years between 1995 and 2008 display a U-shaped time trend. First, beginning in 1998, prices converge, but around 2004 convergence comes to a stop. Most price convergence occurred during the years 2001–2004, around the time that the euro was introduced as circulating (and thus as invoicing/quoting) currency. Another smaller decline is visible from 1998 to 1999, when the euro became the common accounting currency. This is in line with Cavallo, Neiman, and Rigobon (2014), who show that a currency peg (as in Denmark) does not enforce LOP, not even on the internet. Only a common currency (in this study the euro) does. The total decline in dispersion is sizeable. In total, the standard deviation of log prices between EU15 countries under the broad model definition is cut by almost one-half from 1995 to 2004.

This result extends to price ranges, such as the difference between the maximum and the minimum price of a given model across EU15 countries.[17] During the 1990s price differences of 40 percent among EU15 countries were common. In the mid-2000s the range shrunk to about 20 percent, and jumped up again to about 30 percent in the financial crisis. We see that manufacturers are able to maintain a 20 percent price difference permanently even within a market as tightly integrated as the EU15.

3.1.2 Convergence Reversal

We now turn to a more formal analysis of time trends in price dispersion. We first look at a specification that contains a quadratic time trend, controls for the recent EU enlargements and the financial crisis, and a model fixed effect α_m. The fixed effects regression

$$\begin{aligned} \Xi_t^m &= \alpha + \alpha_m + \beta_1 t + \beta_2 t^2 + \Lambda X_t^m \\ &+ \beta_{EU25}\mathbf{I}^{EU25}(t) + \beta_{EU27}\mathbf{I}^{EU27}(t) + \beta_{FC}\mathbf{I}^{FC}(t) + \beta_{AC}\mathbf{I}^{AC}(t) + \varepsilon_t^m, \end{aligned} \tag{2}$$

with $\varepsilon_t^m \overset{iid}{\sim} (0, \sigma_\varepsilon^2)$, contains four binary time indicator variables, capturing important events during the sample period. The expansions of the EU are captured by the binary indicator variables $\mathbf{I}^{EU25}(t)$ and $\mathbf{I}^{EU27}(t)$, which take the value of one in all periods since the EU's expansion to 25 members and 27 members, respectively. The financial crisis is captured by the binary indicator variables $\mathbf{I}^{FC}(t)$ and $\mathbf{I}^{AC}(t)$, where the former takes the value one at the peak of the financial crisis, i.e. in January 2009, and the later in the two periods after that, i.e. in January 2010, and January 2011. X_t^m represents the price of a model in a given period averaged across countries.

Accordingly, α captures the average price dispersion, and β_1 and β_2 any quadratic time trend. Time t is measured in years from November 2003, which in Figure 2 is one of the periods with the lowest dispersion. The coefficients β_{EU25}, β_{EU27}, β_{FC}, β_{AC} capture the impact

[17] See Figure 9 in Online Appendix B.

of the respective events on price dispersion, and the coefficient Λ the effect of price changes over time.

[Table 3 about here.]

We start with a sample restricted to the EU 15 countries, which eliminates any potential, involved changes in dispersion due to the accession of further countries. Column (1) of Table 3 would suggest a convergence of prices since the year 2000 for the full sample period 1993–2011. The accession of new member states to the EU in 2004 did not increase the price dispersion among EU15 countries significantly.

The convergence result in column (1) is, however, conditional on the constraint of a single extremum during the entire 18-year-period 1993–2011. The dummies for the EU enlargement in 2007, for the financial crisis and for its aftermath suggest a prolonged subsequent increase of dispersion. Fitting a quartic time trend (not reported) sends a more differentiated message. In fact, the estimated coefficients of a quartic trend reflect the pattern visible in Figure 2. First, price dispersion increases up to a peak in 1996. Then, for eight years, prices converge. But starting in 2004 dispersion starts to increase again, until the end of the sample, where the quartic time trend reaches its second maximum. Note that this pattern holds even in the EU 15 subsample, so it cannot be attributed to additional countries entering the sample. Even after controlling for the financial crisis with a dummy for observations since the summer of 2008 (January 2009, January 2010, January 2011) the increase in dispersion from 2004 to 2009 prevails.

Columns (3) to (5) expand the view to all countries in the sample. They show that both EU enlargements increased dispersion. This reflects that the accession countries' markets had yet to integrate into the more homogenous EU15 market. This in turn is dwarfed by the jump in dispersion since late 2008, especially visible under the narrow model definition.

In this fixed effects specification the coefficient on car prices reflects time variation in prices. The negative coefficient reveals that price changes are not mirrored by proportional increases in dispersion across countries, which resembles the pattern documented already by Goldberg and Verboven (2001) and Goldberg and Verboven (2005). Price increases are closer to a level shift than to a proportional scaling.

Overall, we have three distinctive episodes of price convergence and divergence.[18] The end of the period studied by Goldberg and Verboven (2004), 1993–2003, coincides with the end of

[18]The studies of the late 1980s and early 1990s (Ginsburgh and Vanhamme, 1989; Kirman and Schueller, 1990; Mertens, 1990; Mertens and Ginsburgh, 1985) arrive at mixed conclusions about price convergence in Europe before 1990. The price differences in the early 1990s were still very large (Verboven, 1996a).

the long convergence period around the turn of the century. As column (2) shows, prices indeed converged in that earlier subsample period from 1998 onwards. Also the specifications based on subsamples starting in the year 2000 shown in columns (3)–(5) agree on an initial decline in dispersion until around the year 2004. After this, however, all three specifications report an increase. Whatever convergence to absolute price parity has been in this market in the 1990's and early 2000's, it has stopped and perhaps even reversed itself after 2004.

How do these results for cars compare to other products? Several studies indicate a slowdown of price convergence in the EU since the turn of the century. Engel, Rogers, Veronese, and Midelfart (2004), for example, find considerable convergence among the prices of consumer goods in the 1990s, the period during which most intra-EU trade barriers were lifted, but no convergence after the year 1999. For washing machines in particular, Fischer (2012) finds hardly any price convergence during the period 1995 to 2005 in a study based on scanner data.[19] Compared to the consumer goods studied in these papers, the convergence trend of car prices lasted longer. We consider it likely that the implementation of additional EU regulation of the car market between 2002 and 2005 gave an additional incentive to car manufacturers to harmonize prices within the EU.

3.2 Effect of a Common Currency

The euro was introduced as bank money in a subset of EU countries in 1999. Table 4 explores whether the adaption of a common currency reduced price dispersion among these countries.

[Table 4 about here.]

To better understand the dynamics of price dispersion inside and outside of the euro area we define dispersion measures conditional on the currency area. Analogous to (1) we calculate dispersion separately for the set of countries with a common currency (EA), i.e. the euro area, and for a set of countries with different currencies (DC), which comprises all countries outside of the euro area and the Netherlands representing the euro. To distinguish these measures from overall dispersion Ξ_t^m we refer to them as $\Xi_t^{m,EA}$ and $\Xi_t^{m,DC}$, respectively. We use these in the regression

$$\Xi_t^{m,\beth} = \alpha + \alpha_m + \beta_1 t + \beta_3 \mathbf{I}^{SC}(t) + \beta_4 \mathbf{I}^{DC}(\beth, t) + \beta_5 \mathbf{I}^{DC}(\beth, t) t$$

[19]For French exporters, however, Mèjean and Schwellnus (2009) find considerable convergence of export prices across EU export destinations between 1995 and 2004. A possible explanation for this is that lower trade barriers attracted smaller firms with no means of implementing PTM to enter the export market.

$$+ \quad \beta_6 \mathbf{I}^{DC}(\sqsupset,t)\mathbf{I}^{SC}(t) + \beta_7 \mathbf{I}^{DC}(\sqsupset,t)\mathbf{I}^{EU25}(t) + \Lambda X_t^m + \varepsilon_t^{m,\sqsupset}, \qquad (3)$$

where $\varepsilon_t^{m,\sqsupset} \overset{iid}{\sim} (0,\sigma_\varepsilon^2)$ and $\sqsupset \in \{EA, DC\}$. $\mathbf{I}^{SC}(t)$ is a binary indicator variable which takes the value one in the three sample periods since the financial crisis, i.e. in January 2009, January 2010, and January 2011. $\mathbf{I}^{EA}(\sqsupset,t)$ is a binary indicator variable which takes the value one for the set of countries $\sqsupset$ outside of the euro area in period t. Accordingly, β_1 captures any linear time trend, and β_3 an increase in price dispersion within the euro area since the financial crisis. Likewise, β_4 is the increment in the level, β_5 in the time trend, and β_6 in the financial crisis effect for countries without a common currency. Because all countries of the EU enlargement used their own national currency, we include the EU25 dummy with coefficient β_7 only for the group of countries without a common currency. An observation in specification (3) is identified by the model and the euro area indicators jointly. Because we include model fixed effects only, Table 4 does not show the common fixed-effects estimator, but the ordinary least squares estimator with model fixed effects.

The second row of Table 4 reveals a drastically larger price dispersion outside of the euro area. Dispersion among countries without a common currency in late 2003 is twice as large as dispersion within the euro area. Despite this, price dispersion is significant even among countries with a common currency (row 1). Obviously, the structure of the new car market in the euro area differs considerably from the one of Internet retail trade in standardized goods, which Cavallo et al. (2014) find to be essentially arbitrage-free. We consider this as a warning not to generalize findings for the products studied in Cavallo et al. (2014) to products that are more customized or distributed offline. Their price behavior, as we show here for cars, can be very different.

The entire price convergence effect of a common currency appears to occur around the time of its adaption. Row 4 of Table 4 provides no conclusive evidence of further declining price dispersion within the euro area, especially not after 2004. However, given the contemporaneous increase in price dispersion among countries with individual currencies (row 5), this is a rather good track record.[20]

The estimated one-time accession effect to the euro area is smaller after 2004. This is not due to a change in the euro area, but because the large group of new EU members, which initially all belonged to the group of countries without a common currency, was more homogenous in

[20]The "outside Euroarea" dummy, $\mathbf{I}^{DC}(\sqsupset,t)$, picks up the difference between the euro-years and the pre-euro-years as well, and the time trends before and after 2004 offset each other over the full sample.

itself than the few incumbent EU countries not participating in the euro. In effect, the 2004 EU enlargement reduced dispersion among this group of countries without a common currency (row 3).

The financial crisis clouds the euro area's record somewhat (rows 6 and 7). At its onset the dispersion within the euro area jumps up, whereas it barely changes within the group of countries without a common currency.

The third and forth column give the clearest-cut analysis of the effect of the common currency. These columns cover only years after the introduction of the euro, and therefore represent – apart from the accession of new countries to the EU and/or the euro area – more a cross-country than an intertemporal comparison. Comparing row 1 with row 2 reveals that in late 2003 the common currency cut price dispersion by about one half.

Overall, the euro appears to permanently lower price dispersion among its members, as noted in Simonovska (2015). In normal times, prices diverge significantly less within the euro area than within a group of countries without a common currency. During the financial crisis, however, the common currency area was subject to an increase in price dispersion not seen among countries with individual currencies.

3.3 Effect of Market Segment

The magnitude and time pattern of price dispersion raises the question about its causes. If cross-country price dispersion was a purely mechanical effect of market frictions, such as asynchronous price adjustment or shipping costs, then dispersion would be similar in all market segments. If, however, price dispersion was the result of active price discrimination by manufacturers, then the underlying pricing strategy might depend on the market segment, and price dispersion would differ by segment.

In this subsection we look for such systematic differences in dispersion between market segments, and its dependence on model features. For this purpose we use the EC classification, which assigns each car model m to one of the following seven segments $s(m)$: *mini cars*, *small cars*, *medium cars*, *large cars*, *executive cars*, *luxury cars*, and *multi-purpose and sports utility cars*. Based on these seven segments we include segment-specific intercepts $\alpha_{s(m)}$ in a random effects regression specified as

$$\Xi_t^m = \alpha + \alpha_{s(m)} + \beta_1 t + \beta_2 t^2 + \beta_{EU25}\mathbf{I}^{EU25}(t) + \beta_{FC}\mathbf{I}^{FC}(t) + \beta_{AC}\mathbf{I}^{AC}(t)$$

$$+ \quad \Lambda X_t^m + \Lambda_{FC}\mathbf{I}^{FC}(t)X_t^m + \Lambda_{AC}\mathbf{I}^{AC}(t)X_t^m + \nu^m + \varepsilon_t^m, \tag{4}$$

where $\nu^m \sim (0, \sigma_\nu^2)$, $\varepsilon_t^m \overset{iid}{\sim} (0, \sigma_\varepsilon^2)$. Model-specific variables are collected in the vector X_t^m with corresponding coefficient vector Λ. This set of variables includes engine power, fuel type, average brand centrality, average car price, and the standard deviation of value added tax (VAT). The averages and standard deviations are taken over the set of countries in which the model is available in period t. A comparison of multiple specifications (not reported in the table) reveals that the effect of the crisis years is amplified by engine power, which renders segment-specific time trends largely redundant. For this reason we include interactions of the crisis dummies with engine power, with corresponding coefficients Λ_{FC} and Λ_{AC}.

[Table 5 about here.]

The upper block of Table 5 sends a strikingly strong message. No matter how we specify a model or which subsample we pick, price dispersion is strongly correlated with the market segment. The more upscale a segment is, the higher is the dispersion. This holds monotonically for the entire lineup of mainstream segments, from mini cars to executive cars. Over the full sample period under the broad model definition (column 1) it even applies to luxury cars, which are insignificant in other specifications due to the relatively few observations in this segment.[21]

The relationship between car price levels and dispersion is similar to our findings in the fixed effects model presented in Table 3. It confirms that, once we control for segment and key car features, the price spread across countries grows subproportionally with price. Therefore price dispersion is not based on price differentiation across price levels alone, but across differential benefits of cars. Because cars in different segments are bad substitutes, car manufacturers can tailor separate price differentiation strategies to each segment. Prices, on the contrary, do not by themselves segment a market, rendering price differentiation strategies based on the price category alone more prone to arbitrage.

The significant coefficients on engine power and fuel type reveal an additional dimension of price differentiation. Prices of powerful cars are more dispersed, prices of diesel cars less. This nicely fits into a story of pricing where exploiting arbitrage opportunities is interlinked with rational consumer decisions. The choice of diesel over petrol might typically be driven by cost and tax considerations, i.e. very rational motivations. These rational buyers might be more

[21] One might suspect that the insignificant coefficient on luxury cars in some specifications is due to a particularly mobile customer base in the luxury segment. Degryse and Verboven (2000) observe a somewhat smaller variation in percentage (but not in absolute) terms in the luxury segment as well.

inclined to compare prices internationally, rendering price differentiation across countries for diesel cars less attractive. The choice of a car with a high engine power might instead be driven more by impulse and lifestyle considerations than by need. These buyers might have less in common with a stylized rational consumer who compares prices before a purchase. This makes international price differentiation for high power cars feasible.

The time trends in Table 5 imply a dispersion minimum around the year 2004, which we have already seen in the previous section, with a jump during the financial crisis and elevated levels since. Columns (3) and (4) show for the EU15 and the EU25, respectively, that during the financial crisis the effect of engine power on dispersion became particularly pronounced. Since the crisis price dispersion increased overall, but the increase was strongest for high power cars. In fact, examining the crisis dummy and its interaction with engine power jointly, we see that for the cars with the weakest engines in the sample (about 40 kW), the impact of the financial crisis was about half of the average effect reported in columns (1) and (2), and insignificant since the year 2010. For cars with the strongest engines in the sample (more than 250 kW), however, price dispersion increased by more than twice the average listed in columns (1) and (2), both in the crisis year 2009 and thereafter.

Taking all these systematic differences between market segments together suggest that manufacturer pricing does not merely follow relative macroeconomic conditions, but reflects active price differentiation across market segments. The origin of price dispersion today is therefore in the realm of industrial organization. It is unlikely to be found in trade barriers and regulation, which apply to all market segments in the same way. Whereas the obstacles to trading cars cross-border continuously declined, a comparison of columns (1) and (3) shows that nothing changed in the lineup of price dispersion with market segments. Furthermore, a look at columns (3) and (4) confirms that this pricing pattern has been inherited by the new EU member states as well.

Two additional coefficients shed some more light on the structure of the European car market. Surprisingly, brands such as Toyota, which are on average centrally positioned, tend to differentiate prices more across countries, whereas brands in niche markets (such as Mini) do not set widely different prices across Europe. Central brands are more substitutable with other brands, so they tend to face stronger competition. This makes one wonder, why brands facing less competition differentiate prices less. The answer might well lie in the realm of brand positioning and marketing, but is outside the scope of this paper.

The regression results also reveal that taxes affect prices. The higher the dispersion of VAT, the more dispersed pre-tax prices tend to be. This would hint towards some market power of manufacturers, if the pre-tax price was lower where VAT is high. To address this and related questions we are now turning to analysing prices directly.

4 Country-Specific Preferences

So far we have looked a conditional moments, that is, on mean and standard deviations across countries conditional on model and time. Now we turn to the prices themselves, and study in particular their relationship to car features.

We first introduce our empirical approach and identify systematic determinants of car prices. We then document the heterogeneity of consumer preferences in the European car market reflected in these prices, and explain how country properties affect pricing. We then describe how marketing can exploit preference differences within Europe, despite a prima facie integrated car market.

4.1 Empirical Approach

Which factors determine the price of a car model in Europe? To answer this question, we study if and how the coefficients in an hedonic regression vary with country properties. Besides carving out differences in the pricing of car properties across countries, we want to examine how differences in the marketing across countries can affect the price. Our data set provides a unique opportunity to do this. We have data on the availability and pricing of several options, in particular air conditioning (AC), anti-breaking system (ABS), and airbags.[22] Recall that p_t^{mc} includes the same available options across countries. However, we also know, for each model, which of these features are offered as standard in a given country. In other words, although the models we compare are identical in terms of what the customer gets, they differ in terms of the menu of options available to the buyers in each country. Thus, for some country-model pairs, AC is part of the standard option bundle. For others, it has to be actively selected for an extra charge. We therefore include in all regressions indicator variables that reflect the offered option bundle. The indicator variable $\mathbf{I}_o^{opt}(m,c,t)$ is one if the option o is included as standard in model

[22] Of these three features only AC varies sufficiently strongly across countries to allow for interaction terms with other variables.

m in country c in period t, i.e. whenever option o is included as standard in the car's list price. These option dummies allow us to measure the effect of including an option as standard – alone, separate from the actual price of this option. They measure an effect that is solely based on an otherwise unobserved change in the presentation or positioning of the car within the market in question, potentially combined with a change in the menu of alternative offers.

Our starting point is the fixed effects regression

$$p_t^{mc} = \alpha + \alpha_{mc} + \alpha_t + \Lambda_1 X_t^m + \Lambda_2 X_t^{mc} + \Gamma Y_t^c + \sum_{o=1}^{3} \mu_o \mathbf{I}_o^{opt}(m,c,t) + \varepsilon_t^{mc}, \tag{5}$$

where $\varepsilon_t^{mc} \overset{iid}{\sim} (0, \sigma_\varepsilon^2)$. X_t^m is a vector of model-specific variables with corresponding coefficient vector Λ_1. These comprise mechanical properties that vary over time: emissions (HC, NO_x, particles) and measured fuel consumption.[23] The time variation stems from the redesign of engines of a given size and power, which changes their efficiency. The vector X_t^{mc} contains country-model-specific variables (distance to plant, registration tax, warranty) with corresponding coefficient vector Λ_2. The vector Y_t^c consists of country-specific variables with corresponding coefficient vector Γ. These include population, GDP per capita, euro area membership, and the rate of VAT.

Because our main interest rests on the interaction of country and model properties, we use for the main analysis the random effects specification

$$\begin{aligned} p_t^{mc} &= \alpha + \alpha_c + \alpha_t + \alpha_m + \Lambda_1 X_t^m + \Lambda_2 X_t^{mc} \\ &+ \Gamma_1 Y_t^c + \Gamma_2 Y^{mc} + \sum_{o=1}^{3} \mu_o \mathbf{I}_o^{opt}(m,c,t) + \lambda \mathbf{I}^{home}(m,c,t) + \nu^{mc} + \varepsilon_t^{mc}, \end{aligned} \tag{6}$$

where $\nu^{mc} \sim (0, \sigma_\nu^2)$ and $\varepsilon_t^{mc} \overset{iid}{\sim} (0, \sigma_\varepsilon^2)$. To control for differences of models across countries in the random effects specification, we augment the set of regressors by Y^{mc}, country-model-specific variables (brand centrality, home brand) which are constant over time. Their coefficient vector is Γ_2. The indicator variable $\mathbf{I}^{home}(m,c,t)$ is one if model m is produced in country c in period t.

[Table 6 about here.]

Table 6 presents the results, all under the narrow model definition for the years 2000 to

[23] CO_2 emissions are collinear with fuel consumption and thus omitted. For brand and segment effects please refer to Online Appendix B.4.

2011. The first column presents the fixed effects specification (5). Only in this specification the car price increases significantly in distance to plant, albeit with an elasticity of only 0.01. By construction, this result rests on within identification, i.e. on changes in assembly locations of a given model. The inclusion of AC as standard comes with a significant surcharge, reflecting the cars' positioning in a higher market segment once AC is included.

Cars with a high in-city fuel consumption, an obvious cost factor for the consumer, are cheaper. For the majority of consumers in Europe, most trips cover short distances, and therefore in-city is for them the relevant consumption metric. The effect of highway fuel consumption, to the contrary, looks very different. The price increases with highway fuel consumption, reflecting most likely more a fun or tuning aspect than a cost aspect in the pricing decision. There is a well-known disconnect between the car use assumed in the formula of calculating average fuel consumption and actual car use. The UK testing agency, for example, assumes that only 36% of driving distance is covered under urban driving conditions. Reassuringly, the actual usage cost is meaningfully reflected in car prices, though, which correlate only with in-city fuel consumption, ignoring the in daily life less relevant highway fuel consumption. This shows how complex consumer preferences can be, but also how subtly they are reflected in prices.

For a given model, and therefore a given engine power, emissions affect prices. High NO_x emissions lower the price, for petrol and even more for diesel cars. Hydrocarbon emissions have no effect on the price of diesel cars, but appear to proxy for some desirable property of petrol cars.

As one would expect, cars in countries with a high total registration tax are priced more modestly, reflecting that manufacturers with some market power absorb some of the tax with lower prices. Interestingly, despite controlling for the registration tax, VAT itself remains significant. Pre-tax car prices start decreasing with VAT only at rates beyond the threshold of 22%. The increase of pre-tax prices for small and falling VAT rates becomes plausible, if the VAT increases are seen are an opportunity for manufacturers to mask pre-tax price increases, and an effect of the attempt of keeping after-tax price changes small. Car prices increase in countries which grow in population or become richer.

Column (2) of the same table presents the analogous random effects specification (6). Neither the sign and significance of individual coefficients nor the overall explanatory power are greatly affected by the switch to random effects. The results are robust to the inclusion of country interaction terms (column 3) and to restricting the sample to the EU15 countries (column

4).

Overall, the distance from the nearest assembly location does not play a big role for prices, implying a small role for transportation costs in price determination. Likewise prices in the euro area are not systematically different. More central brands charge lower prices, possibly a concession to less market power. Domestic brands are on average somewhat cheaper, but this effect is very heterogenous across countries, as the results in the next section will reveal.

4.2 Heterogeneous Market

In this section we focus on the drivers of price heterogeneity and discuss the interaction terms not shown in column (3) of Table 6. We lift the common assumption that consumers value a car property (or, more generically, "quality" as in Goldberg and Verboven (2001)) equally much in all countries. Specifically, we expand the random effects specification (6) with country interaction terms. We interact elements of Y^{mc} (home brand), X_t^m (fuel consumption), X_t^{mc} (registration tax), the AC indicator variable $\mathbf{I}_{AC}^{opt}(m,c,t)$ and fuel type (otherwise absorbed by the model fixed effect) with country indicators and add interactions of the country and time effects, α_{ct}.

[Table 7 about here.]

Zooming into the home brand coefficients in Table 7 uncovers large heterogeneity across countries even in the home brand effect. In the Czech Republic, France and Italy, domestic brands sell at a premium. In contrast, they sell at a discount in Germany, Sweden, and the UK. Because we control for the actual assembly location, this home country effect is a pure demand side effect.[24]

These results in Table 7 hold in a relative sense, i.e. for a given model. They do not imply that domestic cars sold in Germany are cheap relative to other cars. Brand fixed effects, in Table 6 absorbed by the model fixed effects, of German brands are relatively high, so that despite the negative home brand effect German brands are more expensive than other brands in Germany. Nevertheless, this is another example of how different preferences support significant price differences.

[Figure 3 about here.]

[24]The domestic market share of brands is very stable. For example, the market share of French car brands in France was very close to 60% during the years 2000-2011. In Germany, the market share of German car brands was close to 57% during 2000–2011.

Car demand strongly responds to fuel taxation (Klier and Linn, 2010), mirrored in our data in the lower prices charged for cars with high in-city fuel consumption in almost all countries. The pricing of (in-city) fuel consumption is strictly country- or region-specific. Figure 3 shows that it varies systematically with fuel taxation, which itself might reflect country-specific preferences. In most countries, a reduction of fuel consumption comes with price increase, reflected in the negative coefficient on the vertical axis. The size of this reduction depends on the opportunity cost of the saved fuel, and in particular on the fuel tax in the respective country. Figure 3 shows that in high tax countries with a petrol tax of more than 55 cents per liter car prices increase by more than one percent for each liter per 100 kilometers saved. No matter whether one views petrol taxation as the result or as a determinant of consumer preferences in a given country, the pricing differences within the EU are large. Consumers in Sweden, Finland on the one side, and in Poland and Hungary on the other appear highly sensitive to fuel consumption, but in opposite directions. The coefficients on highway fuel consumption vary across countries as well, but this variation is unrelated to observables such as the size of the highway network or income.

This heterogeneity of consumers continues in the pricing of diesel cars. The average price difference between diesel and petrol cars varies widely between countries. The surcharge for diesel engines between the country with the lowest (UK) and the highest (Denmark) surcharge for diesel engines differs by more than 14%. It is strongly negatively correlated with the tax rate on diesel fuel (correlation coefficient -0.49), but not with the difference between petrol and diesel tax.

In all countries except Romania the pre-tax car price is the lower, the higher the registration tax is. This suggests that manufacturers take the demand effect of a tax change into account, which can again occur only if they have at least some market power. Manufacturers offset taxation spikes most strongly in Eastern Europe, and barely in Cyprus, Luxembourg and Denmark. Assuming that the market power of manufacturers is similar in all countries, this points towards large differences in demand elasticity in Europe.

The country-time interaction terms[25] reveal that conditional on the other covariates Sweden and Germany are the most expensive countries, whereas Cyprus and Greece are cheapest. The intercepts of both groups of countries have opposite sign and differ significantly from the one of the Netherlands. The price difference suggests that manufacturers exploit the difference in market structure between these two groups, i.e. that they do not consider the European Union

[25] See Table 17 in Online Appendix B.4.

as integrated, arbitrage-free market.

This section presented some examples of how differently certain car features are priced within Europe and identified some determinants of price differences between countries. Manufacturers follow a strategy already observed by Mertens and Ginsburgh (1985), who noted that price discrimination is much larger than product differentiation in a hedonic price regression, and that car manufacturers "use product lines to discriminate across EU countries" (Ginsburgh and Weber, 2002). Some car features, for example certain engine sizes, are offered only in a few countries, which allows for a direct way of segmenting the market. Engines could, in principle, be tailored to each individual market. The cars would become different products, sustaining a price wedge between countries limited only by the elasticity of demand with respect to price and engine specifications. Tailoring a car directly to each country (marketing region) is more realistic today than ever before, as more and more car functions are handled by easy-to-replace software components. Changing the engine control software, for example, can radically change the engine's performance and emissions. This tailoring of software can be done without any loss of economies of scale in the production process. We would therefore expect an ever more fragmented car market in the future.

Obviously, we cannot test a conjecture on tailored software, lacking information about emission differences of car models across Europe. To our knowledge, these were the same throughout Europe during the sample period. Assuming that the cars in our sample were indeed completely identical across countries (apart from the location and nationality of the dealership), then how could manufacturers sustain price differences within Europe? Our dataset hints at marketing as one potential strategy. We explore this in the next section.

4.3 Bundling and Marketing

We have shown so far that cars are priced to market and take differences in preferences across countries into account. The cars in our sample are, however, technically identical, so that cross-country arbitrage should render any such price discrimination unsustainable. The puzzling question is therefore, how these price differentials can persist in an integrated, competitive market like the EU, for mechanically identical cars.

The examples of region-specific pricing in the previous section are based on observable features. Region-specific pricing is not limited to physical car features, though. It extends to soft factors, for example a car's marketing. This is usually not observable to researchers. Our dataset allows us to look into one aspect of this, the bundling of AC.

[Figure 4 about here.]

Identical cars, i.e. cars with the same features, can differ in price if the features are priced in different bundles. Consider, for example, the pricing of a car with AC. The AC can either be included as standard equipment, or be selected by the consumer from a list of optional, separately priced extras. The price of a car with AC purchased as bundle might differ from the price of a car with AC purchased as a separately price option. Whether AC is included as standard or offered as an option has no effect on the production process, because all the cars that we consider here are available with AC, so the production process in either case must accommodate AC installation. In this experiment the physical car is therefore unchanged, only its marketing varies.[26]

This holds internationally as well, where the bundles available differ by country. In our sample, only 62% of the models in Denmark include AC as standard, whereas the respective figure for Italy was 80%. Likewise, 9% of models in the UK had no AC option available, but only 1% in Italy (Table 1). Figure 4 illustrates that such a difference in bundles indeed pushes the real exchange rate away from parity. The cars in both histograms are identical, and in particular they all feature an AC. The only difference is that the dark, tight histogram contains only cars offered in both countries with the same AC bundle, i.e. either bundled in both or bundled in neither of the two countries. The light, spread-out histogram contains only cars that are offered in different bundles in a given country pair, i.e. bundled in the one and not bundled in the other country.

The fourth row of Table 6 shows that on average cars with bundled AC are more expensive than the estimated price of the separate components.[27] They appear to be marketed to a less price-sensitive customer segment. Obviously, this is not a feasible strategy in regions where an AC is of no use. Unsurprisingly, therefore, the countries in our sample differ widely in the availability and the price of bundles. More than one quarter of observations in our sample do not include AC as a standard feature. Column 7 of Table 1 highlights two exceptions: In Cyprus

[26]The working paper version (Dvir and Strasser, 2014) illustrates in a simple two-country model how car manufacturers can use bundling to differentiate products between countries. The key requirement is that car customers in one country disagree more about the value of a certain car feature than in the other country.

[27]For each model, we observe either the price of the AC bundle, or separately the price of the car and the price of the AC option. We never observe both at the same time. Our estimate of the bundle surcharge is based on time variation in AC bundling and on cross-country differences of the bundle.

and Malta almost all cars feature AC as standard. Ireland and UK are the countries with the most observations of no AC being available at all.

[Figure 5 about here.]

Indeed, the surcharge is not randomly applied throughout Europe. A bundling surcharge can only be justified by a higher market positioning of cars with standard AC than of cars without standard AC. AC bundle surcharges are most prominent in Hungary, Slovakia and the UK. Figure 5 highlights a fairly ad hoc approach to differentiation: differentiation based on the utility derived from an AC, which depends on the climate and thus the temperature in the respective countries. The plot is based on the coefficients on the AC bundle in column (3) of Table 6. It uncovers two clusters of countries. The first cluster consists of the Mediterranean countries Greece, Italy, Portugal and Spain. Their climate renders an AC a necessity, and there is almost no price effect of AC bundling. The second cluster covers the rest of Europe, where a car without AC might be considered acceptable. Among these countries, the bundle surcharge increases with the summer temperature. In the center of Europe a car with bundled AC appears to be targeted at a less price-sensitive customer segment – a strategy with might fail in the North because of the limited usefulness of AC in that region. The implied alignment of the bundling surcharge with latitude might also reflect an attempt to minimize the stimulus for active arbitrage, i.e. avoiding customers noticing much lower prices in a neighboring country.

[Table 8 about here.]

The AC bundle surcharge is linked to the average maximum daily temperature in the hottest month. Table 8 shows that in both hot and cool countries the AC bundle surcharge increases in temperature. However, to reach a positive surcharge level, we need only 20 degrees Celsius in cool, but 30 degrees Celsius in hot countries. The bundling surcharge is therefore exploiting the "desire for AC". In the very south it is a necessity, however, so these countries show effectively almost no price response.

The marketing to the Southern countries in the second cluster appears to differ. In these countries AC bundling deviates most frequently from our reference country, the Netherlands, between 11% (Portugal) and 25% (Greece) of the time. Breaking up the overall effect of AC bundling (1.28) in column 1 of Table 6 by synchronization with the Netherlands – not shown in the table – reveals that only bundles synchronized with the Netherlands increase prices (1.57).

When AC is bundled only in the country of interest, but not in the Netherlands, which is more common in Southern countries, then the price (insignificantly) decreases (-0.62). Price sensitive consumers in Northern countries may not benefit from this bundling discount in the South, because they do not value AC as much.

We would like to emphasize that the feature AC is only one example of a feature that can be exploited in country-specific marketing. Combined with other car features, missing in our dataset, bundles can differentiate cars along multiple dimensions and thus can sustain larger price differentials. Overall, the evidence on AC bundling shows that pure marketing differences, and among them in particular country-specific bundling, can explain some of the international price differentials.

4.4 Country Effects

The country-time effects in the price level regression (6) deserve further attention, because they might conceal additional systematic price differentiation across countries. In fact, Crucini and Yilmazkuday (2014) show that the dispersion of long-run time averages is considerably larger than the dispersion of time-series deviations from these averages. The price dispersion is large, for example in the Crucini, Telmer, and Zachariadis (2005) good-by-good study of LOP deviations between EU countries during the years 1975–1990. Nevertheless, price differences for these retails goods and services are centered around zero for each country pair after controlling income and taxation differences. The price differences across countries that we find for cars are large and significant, even after controlling for registration tax (Table 17 in Online Appendix B.4). Clearly, cars do not behave like a median product. Whereas the results of Crucini et al. (2005) reassure us that overpriced and underpriced products average out, our results overshadow this view with the worrying observation that the most expensive product is far from the median of the distribution.[28]

Obviously, passenger cars are a rather complex product. This provides many fulcra for price differentiation. 43% of the variation in the 27 country intercepts can be explained by

[28] Our results for the European car market extend the results for retail goods in Crucini et al. (2005) to the big ticket consumer goods segment. Despite the higher price of the products in our sample, and accordingly the larger incentive to collect information on cross-border arbitrage opportunities, we find significant price dispersion. This is even more striking when considering that our results are based on more recent data. During our sampling period the European market had been more integrated than during the years 1975–1990 studied in Crucini et al. (2005). Cross-sectional price dispersion is negatively related to the tradeability of the product, and positively related to share of non-traded content. Thus one might expect that in the car market the price dispersion would be smaller than in the retail market studied by Crucini et al. (2005), but this is not the case.

only two variables:[29] The intercepts are decreasing in temperature, and increasing in the size of the economy, measured by real GDP. Allowing for lower prices in the East by including the longitude in the regression increases the R^2 to 48%. Income per capita captures less of the variation than any geographic or climatic factor alone.

The bottom line is that country effects are anything but random. Countries are marketing regions. The country effects vary systematically with observable specifics of the respective marketing region, which for primarily historical reasons coincide with countries. The price difference between a pair of countries does not depend so much on their physical distance, but in how dissimilar they are from a marketing perspective. Accordingly, we suggest to include in discussions of border effects besides physical distance and cultural distance also metrics of market dissimilarity.

The price differentiation we observe is not limited to the car market. Already Haskel and Wolf (2001) suggest that "strategic pricing" might explain this price pattern. Burstein and Jaimovich (2012) show that consumer goods produced in the same location are subject to pricing-to-market. They detect differences in the wholesale price of the same product across regions, both in their data and based on interviews with retail managers. The car manufacturers in our sample do just the same.

5 Aggregate Country Effects and Shocks

The large impact of the financial crisis on price dispersion warrants a more detailed look at the effect of aggregate shocks on price dispersion. In this section we study the impact of two aggregate shocks, exchange rate and business cycle fluctuations, on car prices measured in local currency units (LCU). After that, we study the behavior of car prices during the financial crisis.

5.1 Country-Specific Shocks and Policies

How do car prices respond to aggregate shocks? To answer this question, we regress the percentage change in the pre-tax local currency price on changes of the exchange rate and economic growth. Denoting the percentage change of the euro exchange rate, expressed in LCU per euro, during the most recent intersurvey period by Δe_t^c, we can define the change of the local currency

[29]Because the set of countries covered by our sample expands with time, we have an unbalanced sample. In this analysis, we first remove common time effects and then average across time.

price as $\Delta\tilde{p}_t^{mc} = p_t^{mc} - p_{t-1}^{mc} + \Delta e_t^c$. In the linear regression

$$\Delta\tilde{p}_t^{mc} = \alpha + \alpha_{mc} + \beta_1 \Delta e_t^c + \beta_2 \Delta^{2J} e_t^c + \lambda X_t^m + \gamma Y_t^c + \varepsilon_t^{mc} \tag{7}$$

with $\varepsilon_t^{mc} \overset{iid}{\sim} (0, \sigma_\varepsilon^2)$ we include Δe_t^c, the percentage change of the euro exchange rate since the previous survey, to ensure that the results for LCU and for euro prices are equivalent. The other explanatory variables are, first, the rate of change of the exchange rate during the past two years, $\Delta^{2J} e_t^c$. Second, the year-over-year growth rate of per-capita GDP, measured in euros at purchasing power parity, during the calendar year before the survey, Y_t^c. And finally, the AC bundling indicator variable, X_t^m.

[Table 9 about here.]

The coefficients β_1 and β_2 in column (1) of Table 9 offset each other, which means that exchange rate fluctuations do not affect local currency prices instantaneously. In the short run prices remain fixed in local currency, but column (2) qualifies this to imported cars only. Over the longer horizon of two years a depreciation of the local currency leads to a modest price increase of imported cars of about 10% of the depreciation amount. The price of domestic cars falls initially, possibly due to a weak economy reflected in the weak currency, but returns to the original level within two years. The European new car market is therefore no exception to incomplete and slow exchange rate pass-through.

The business cycle barely affects prices directly. An increase in per-capita GDP, measured at purchasing power parity, during the calendar year before the survey by 4% leads to an insignificant average price increase of about 0.1%. Including current and past real GDP growth as an instrument for two-year exchange rate changes to break a potential endogeneity of longer-term exchange rate changes amplifies these results (column 4).

The narrow model definition used in Table 9 ensures as before that the price changes are for technically identical cars. But, as we have argued throughout this paper, it does not capture how the car was offered. Column (3) reaffirms how important a change in the presentation of a product can be. A switch in the way the AC is sold affects prices. As before, including AC as a standard feature comes with a price increase of about 1%.

5.2 Financial Crisis of 2008/2009

In Section 3 the jump in price dispersion in the financial crisis stands out as exceptional. All specifications (Tables 3, 4 and 5) show a significant increase in price dispersion since early 2009. Prices appear to have drastically changed in late 2008. This section explores the heterogeneity behind these large price movements. We ask in particular: Did all brands cut prices in a similar way? Which countries experienced the largest price cuts? And, importantly: Did the exchange rate regime matter?

[Figure 6 about here.]

As a benchmark against which we compare the effect of the crisis, we first look at the 2000–2011 period for all 27 EU countries. For a given model, price increases during the years 2000–2011 were small. When we weight periods by length, we get an average price increase of 1.6% p.a. for this period. In most countries the average annual price increase (over all brands) during the years 2000–2011 is in the 0%–2% p.a. range. The main exceptions are the UK with a decline of about 0.9% p.a. and Poland with an increase of 3.7% p.a. since joining the EU.[30]

Figure 6 shows the average changes in pre-tax car prices as solid black dash. The upper panel shows that the financial crisis 2008/2009 is the only period with an overall price decrease for existing models (-1.0%). It is not the case, however, that all prices declined from 2008 to 2009. Unlike in Calvo pricing, firms change their prices all the time. They just do not always change them in the expected direction. Averaging over many periods, however, an upward time trend emerges. The non-change periods of Calvo pricing could thus be interpreted as periods during which firms change prices for whatever reason by less than or in the opposite direction of, the expected inflation rate.

In this vein, the price drop during 2008 is driven by a steep price decrease for some models in some countries. The bars around the black dashes in Figure 6 cover one standard deviation of price changes across models, separately for models with price changes above and for models with price changes below the average. The figure illustrates that the standard deviation of above-average price changes does not differ in 2009 from the other years. The lower tail,

[30]These annual price increases differ from the inflation rate of cars, of course, because they exclude price increases at the introduction of new car models. Under the broad model definition, changes in car specifications can affect prices. This is reflected in the larger variation of price changes in the lower panel of Figure 6. Even when limiting the sample to EU 15 countries, the heterogeneity of models with respect to price increases is very pronounced during the years 2000–2007. During this period, some specification changes entailed large price increases. This indicates that whereas manufacturers tend avoid large price increases of identical cars, they are more willing to increase prices when the price comparison is hampered by a change in specifications.

however, becomes very spread out, reflecting that exceptionally large price cuts, not price increases, explain the increase in dispersion. The following years indicate a tendency to undo the price decline during 2008. Prices increase by about 1% and 2% in 2009/2010 and 2010/2011 respectively.

What explains the increased dispersion in 2009? The pricing during the years 2007–2010 differs strongly by brand. Some brands responded with massive price cuts, others barely changed the prices of their existing models. Daihatsu, BMW, and Fiat did not reduce their average prices between any two sampling dates between May 2007 and January 2010. On the other end of the spectrum are brands with more than 3% price cuts in 2008, namely Land Rover and Volvo, and brands with extreme price cuts of more than 5%, namely Alfa Romeo and Skoda. These brands are also among the ones seeing the smallest price increases in 2009.

The price response of car segments is just as heterogeneous. The mini car segment did not experience any year with a notable price decline during the years 2007–2011. It is the only segment with a price increase (4.3%) during the financial crisis. The strongest declines were in the multipurpose (-3.1%), medium car (-2.6%), and executive car (-1.9%) segment. We conclude that the effect of the financial crisis on pricing depends strongly on the manufacturer situation and segment-specific demand elasticity. Subsidiaries in the process of changing owners (Land Rover, Saab, Volvo) had to cut prices more. The differential price response within the same conglomerate (VW and Skoda, Fiat and Alfa Romeo) suggests a highly brand-specific pricing strategy, i.e. an asymmetric distribution of funds within a conglomerate when it faces financial constraints.

[Table 10 about here.]

With the exception of the year 2009 the euro area has seen no across-the-board price declines since the year 2000. Even during the year 2009 the price decline was with -0.5% relatively small. Outside the euro area the price declined more strongly and earlier, by 4.2% during the year 2008. Column (3) of Table 10 reports that prices even increased – by more than 1% – in the euro area during 2008. Some of the price reduction in the euro area in the following year might be a tribute to narrowing that price gap to countries outside of the euro area again.

Columns (1) and (2) of Table 10 refer to prices in countries outside of the euro area. Examining row 1 of these columns jointly uncovers an example of almost perfect pricing to market. For models not produced in the respective country, which by construction is the prevailing case, prices in local currency units (LCU) barely changed. Assuming that these cars were imported from the euro area, the exchange rate pass-through was zero. Interestingly, during the same period, the price tag on cars produced domestically was reduced by 2.3%. Taking these two pieces of evidence together reveals that the pricing of domestic and foreign produced cars is not that different. The revenue cut in terms of the manufacturers' respective home currency is (outside the euro area) even larger for imported cars than for domestic cars, despite a stronger price decline in LCU terms for domestically produced cars. Domestic cars were discounted by 2.3% in response to local demand shifts, and foreign manufactures cut prices in their home currency (EUR) by 3.8% by keeping LCU prices constant. Given the weak local demand (reflected in the price drop of domestically produced cars) manufacturers did not dare to pass on a 5% price increase in LCU terms in that period – which a full pass-through would have implied.

This behaviour resembles the pricing-to-market by Irish producers in manufacturing, mining and utilities that Fitzgerald and Haller (2014) document for the years 1995 to 2005. They find that the markup fully offsets exchange rate changes, even when conditioning on price changes. The pricing of car manufacturers during the crisis, when prices (and costs) changed in most countries, shows the same tendency to absorb exchange change fluctuations within the markup. During the market collapse in 2008 importers may have resorted to a constant LCU price as default price reduction. This pricing-to-market appears mechanical with LCU prices seemingly fixed and exchange rates fluctuating, but in light of the price reductions of domestically produced cars it is in fact a conscientiously chosen pricing strategy, similar to the pricing of consumer goods in Burstein and Jaimovich (2012).

Domestic production implies less price increases (or more drastic cuts) during 2008, maybe due to a disproportionally strong increase in demand elasticity for domestic goods. The strong price decline of domestic models of 15% in euro terms in countries outside the euro area therefore turns out to be a combination of local price declines (Czech Republic, Slovakia, Sweden) and a depreciation of these currencies against the euro (Poland, Sweden, UK).

6 Conclusion

Prices are widely dispersed across countries. Passenger cars are no exception, even in a market as integrated as the single market of the EU. Model-specific real exchange rates of cars vary significantly, and they vary differently for each model. In this paper we show that these price differences are anything but random; they are systematic. Car features are priced very heterogeneously in Europe. These price differences ground on the heterogeneity of consumer preferences and regulation within the EU. We find evidence for price differentiation based on, e.g., regulatory (fuel tax), market (market power, market size) and climatic (pricing of AC) differences. But price differentiation does not stop at country differences that are exogenous to manufactures. We find evidence that the marketing of identical products differs by country. Heterogenous brand positioning is reflected in large differences of the home brand effect across countries. Centrally positioned brands display lower price levels but wider price dispersion across countries. Even the market segment matters: Price dispersion grows monotonically with the market segment. Higher segments might have a less elastic demand, and we conjecture that the higher complexity of a car in upper segments is one reason for this. The higher complexity permits the marketing of a multiplicity of different car versions of a mechanically identical model. An extreme example of versioning might be price differentiation via AC bundling that we describe in this paper.

Overall, we find strong evidence of cross-country price differentiation actively managed by firms. The long-term violations of absolute LOP are founded on systematic pricing differences of individual product features.

In 2008, the European Commission (EC) revised the block exemption regulation, a central regulation governing the European car market, based on the notion that car prices within Europe have converged (European Commission, 2008). Using official EC data, we indeed find convergence of car prices until 2004. Since 2004, however, price convergence has come to a halt. Prices appear to have converged in anticipation of the regulatory push towards more market integration between 2002 and 2005, rather than adjusting to it thereafter. This suggests, again, a proactive price adjustment by manufacturers, well before international arbitrage might have kicked in.

We explain the lack of further price convergence in the European car market after 2004 with active product differentiation. At this point, market segmentation along country-specific versions and bundles appears to dominate market segmentation along administrative barriers. If the elimination of border effects was desired, EC competition policy would have go beyond regulating market access and removing administrative barriers. As already Adams and Yellen (1976) have suggested, it would have to ensure a "competitive supply of each decomposable good separately" (Adams and Yellen, 1976, p.497f). This would require mandatory unbundling of non-essential car components (such as GPS, audio, AC, color, sunroof) and openly accessible interfaces, similar to the forced unbundling of Microsoft's Internet Explorer from its operating system, and offering the resulting menu of identical options in all countries. This would go much further than the technical harmonization currently envisioned in the reform of the EC's vehicle type-approval system. It would, in effect, limit the scope for differential marketing.

Heterogenous marketing does not widen borders, but mirrors spatial diversity. Even integrated markets might contain regional differences in preferences. Often regions of common preferences coincide with countries. This renders countries natural marketing regions, even in an integrated market.

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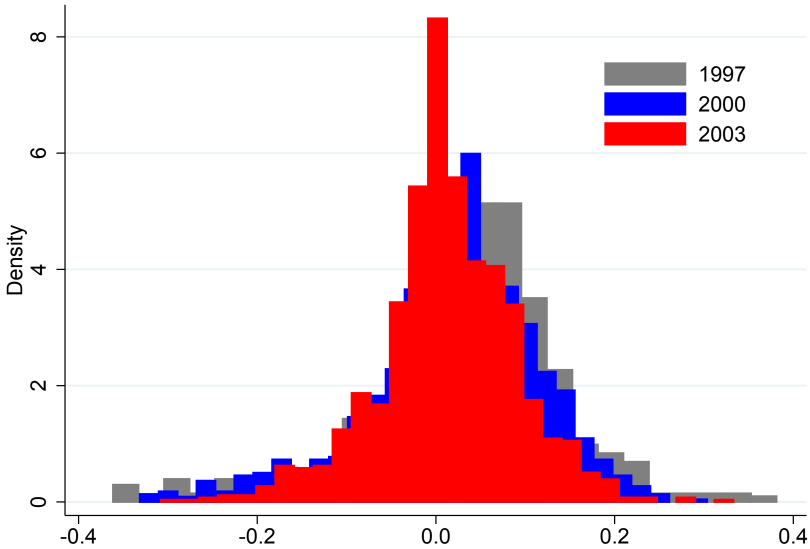
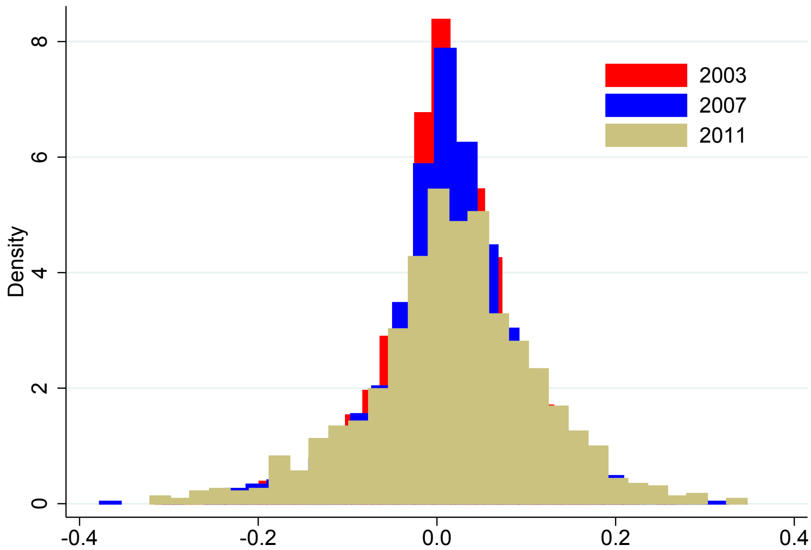
Figure 1: Frequency Distribution of Model-Specific Real Exchange Rates

(a) 1997-2003

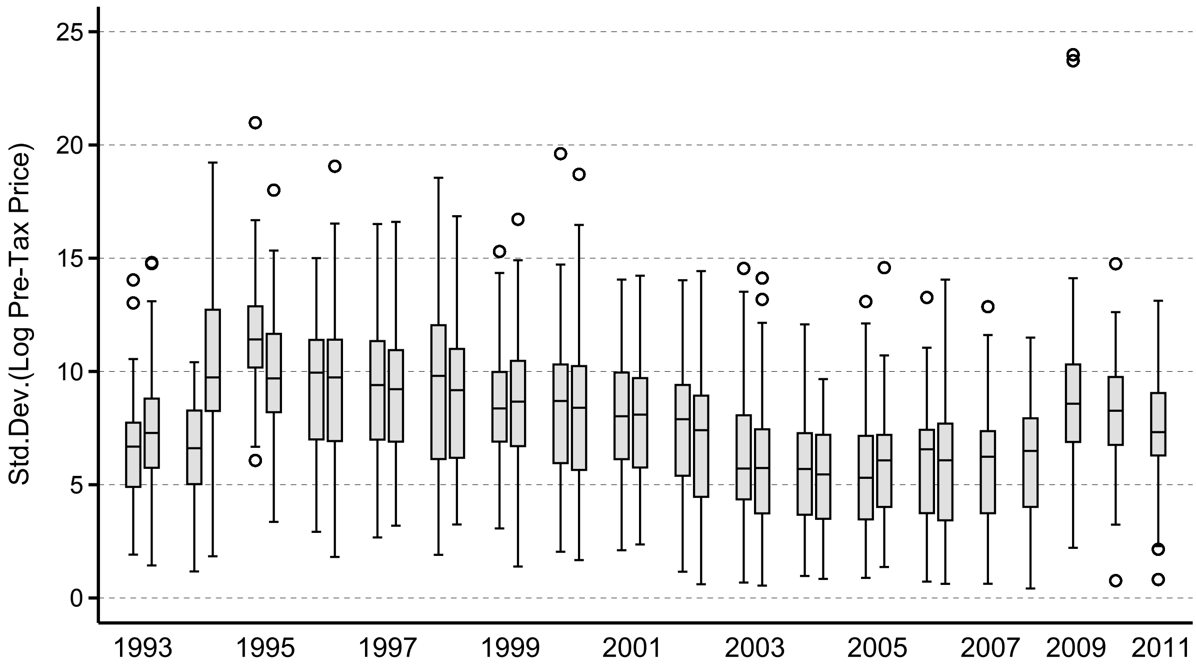


(b) 2003-2011



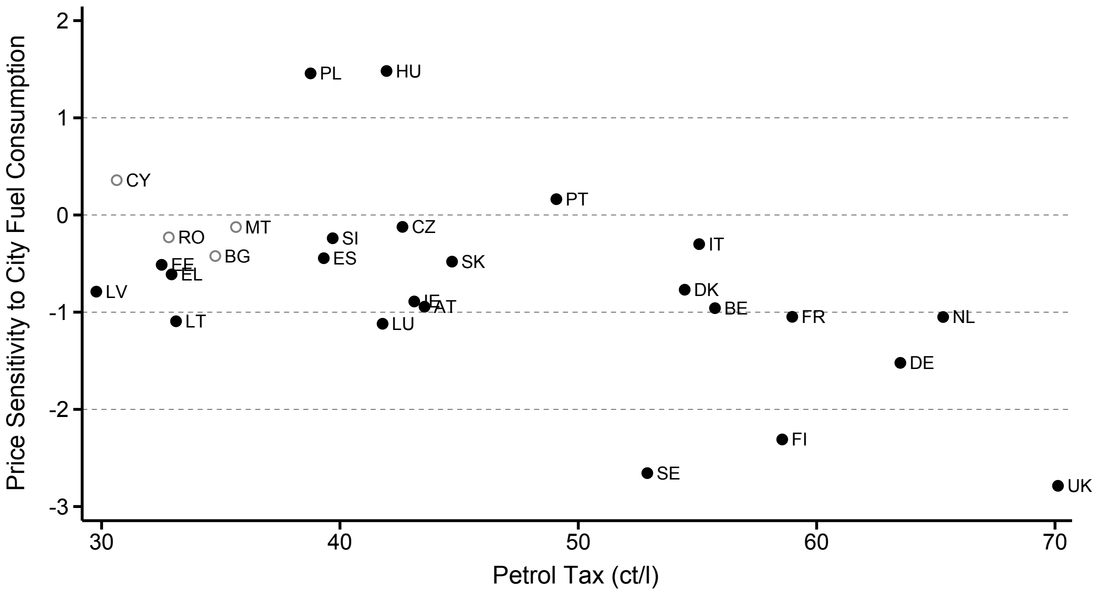
The histogram shows the frequency distribution of model-specific real exchange rates, r_t^{mc}. Broad model definition, EU 15 countries only. The upper panel shows the months May 1997 ($\sigma = 0.110$), May 2000 ($\sigma = 0.096$), and May 2003 ($\sigma = 0.076$), whereas the lower panel shows the months November 2003 ($\sigma = 0.071$), May 2007 ($\sigma = 0.078$) and January 2011 ($\sigma = 0.097$).

Figure 2: Log Price Dispersion



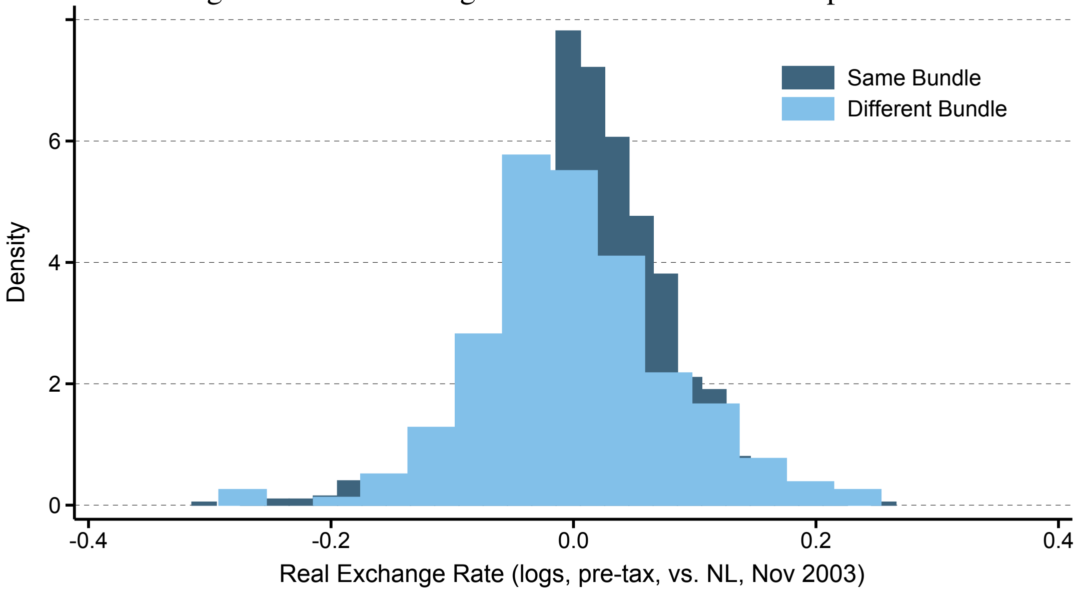
The graph shows the distribution of Ξ_t^m across models, i.e. of the model-specific cross-country dispersion of log prices. Broad model definition. EU 15 countries only. Boxes represent the 25$^{\text{th}}$–75$^{\text{th}}$ percentile range, with the horizontal line denoting the median. The lower whisker ends at the “largest observed value below the 25$^{\text{th}}$ percentile minus 1.5 interquartile ranges” threshold, and the upper whisker ends at the “smallest observed value above the 75$^{\text{th}}$ percentile plus 1.5 interquartile ranges” threshold. Circles represent outliers.

Figure 3: Price Sensitivity to Fuel Consumption by Fuel Tax



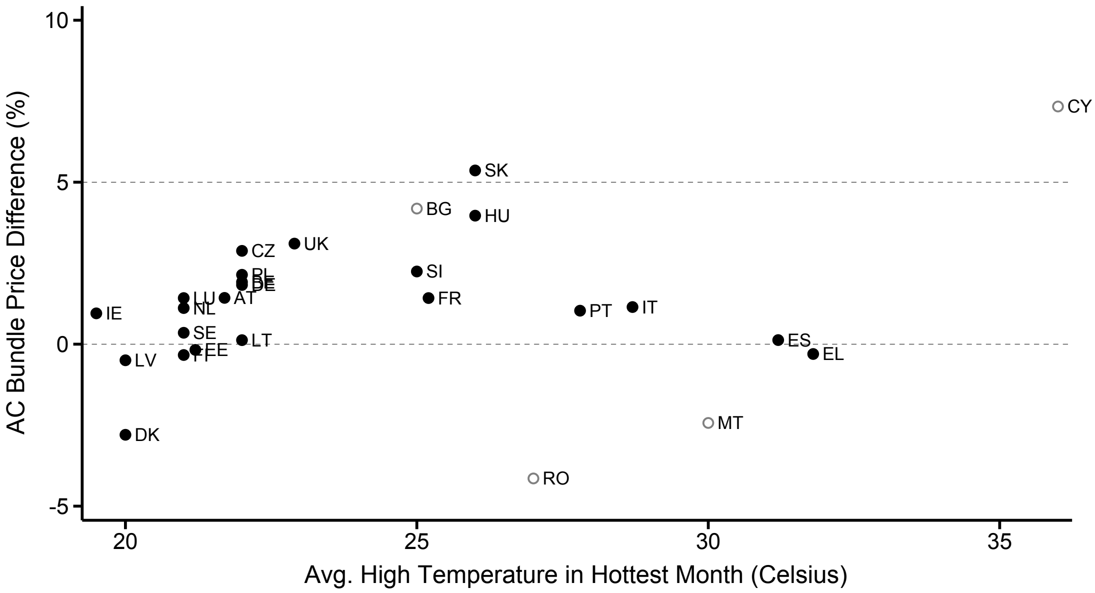
The graph plots the coefficients on city fuel consumption (l/100km) against the tax on petrol fuel (ct/l). Based on specification (3) in Table 6. The estimates in light grey (Bulgaria, Cyprus, Malta, Romania) are based on a very small sample.

Figure 4: AC Bundling and International Price Dispersion



The graph shows the frequency distribution of the real exchange rate against the Netherlands in November 2003. The dark histogram covers 997 cars for which AC is standard equipment in either both or neither of the two countries ($\sigma = 0.069$). The light histogram covers 200 cars for which AC is standard equipment in the one, and optional equipment in the other country, or vice versa ($\sigma = 0.082$). Narrow model definition, EU15 countries only.

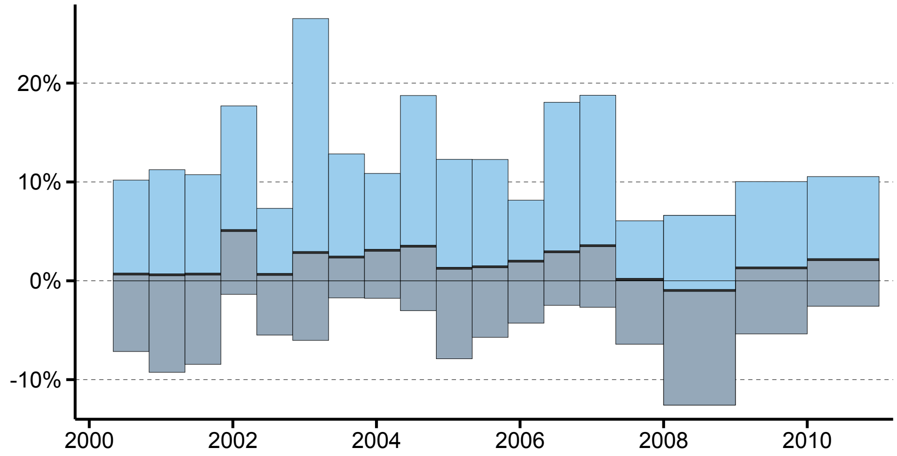
Figure 5: Determinants of AC Price Difference



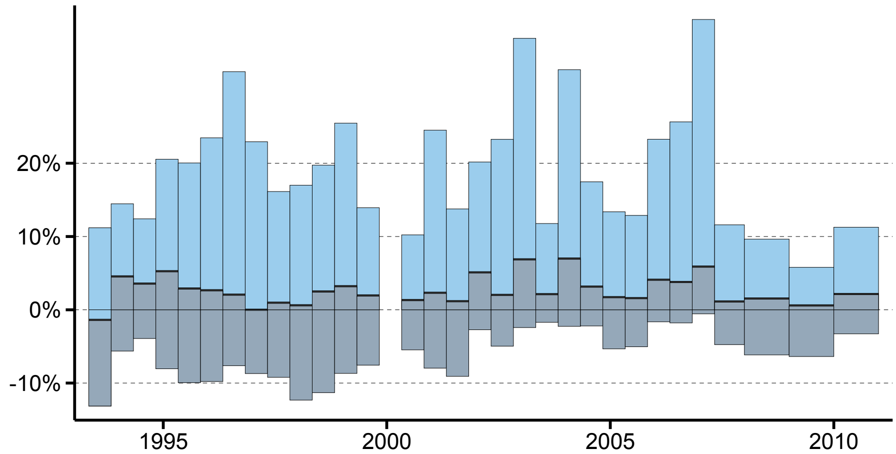
The graph plots the coefficients on bundled AC by country from specification (3) in Table 6 against the maximum average temperature. The graph shows the discount (-) or surcharge (+) in percent by country when AC is included as standard option. Based on specification (3) in Table 6. The horizontal axis gives the average daily high temperature in the hottest month measured in degrees Celsius. The estimates in light grey (Bulgaria, Cyprus, Malta, Romania) are based on a very small sample.

Figure 6: Average and Standard Deviation of Percentage Pre-Tax Price Change

(a) Narrow Model, EU 27



(b) Broad Model, EU 15



The graphs show the average annualized percentage change of the pre-tax euro car price as solid black dash. The shaded area marks a one standard deviation band around the mean, conditional on whether the price change is more or less than the average change. Weighting such that every country-time price increase rate has equal weight in aggregate average. The upper panel is based on the narrow model definition, for all EU 27 countries available. The lower panel is based on the broad model definition and restricted to prices in EU 15 countries only.

Table 1: Absolute Price Deviation from EU Average, by Country

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1993–2011		2000–2011			2000–2011		
	Abs. Price Deviation				Obs.	AC n.a.	AC opt.	AC std.
country	mean	sd.	mean	sd.	#	%	%	%
Netherlands	584	556	563	508	2003	2	31	66
Spain	642	567	616	541	1900	3	21	76
Belgium	666	563	699	575	2031	3	30	67
Luxembourg	666	584	691	563	1911	3	31	66
France	733	661	718	678	2006	3	18	78
Italy	740	765	658	631	1938	1	19	80
Portugal	774	846	751	757	1780	4	22	74
Austria	846	659	850	629	1966	3	26	71
Greece	925	1035	844	921	1434	3	10	83
Slovenia	931	805	931	805	932	1	16	83
Estonia	943	716	943	716	865	1	22	77
Lithuania	945	856	945	856	877	1	22	77
Latvia	949	824	949	824	867	1	21	77
Ireland	961	946	1008	990	1757	8	26	62
Bulgaria	1033	869	1033	869	415	0	15	85
Slovakia	1066	1015	1066	1015	944	2	19	78
Cyprus	1114	1235	1114	1235	620	0	3	94
Germany	1124	703	1167	714	2041	2	29	69
UK	1183	1402	1333	1581	1925	9	17	73
Finland	1211	1307	1073	945	1619	4	24	68
Hungary	1255	989	1255	989	1008	1	20	78
Romania	1272	1221	1272	1221	401	0	10	90
Sweden	1314	1345	1420	1441	1785	4	28	68
Malta	1354	1158	1354	1158	556	1	7	88
Czech Rep.	1398	1214	1398	1214	1026	1	25	73
Poland	1417	1405	1417	1405	993	2	21	77
Denmark	2135	1518	2014	1546	1748	6	32	62
all	980	1011	996	1013	37348	3	23	73

Columns (1)–(4) list the mean and standard deviation of the absolute deviation of the pre-tax car price in a given country from the EU average, calculated separately for each (narrow) model and survey, in euros. The countries are sorted by column (1). Models available in only one country are excluded. Column (5) provides a breakdown of observations by country. Columns (6)–(8) report the percent of car observations without an AC option, with AC as optional extra, and with bundled AC, respectively. Any difference of the sum of columns (6)–(8) to 100% is due to observations without AC information and due to rounding.

Table 2: Price Variation by Model Definition and Tax Inclusion

			(1)	(2)	(3)	(4)
				Pre-Tax		After-Tax
		sample period	2000–2011	2000–2011	1993–2011	1993–2011
	in % of	model definition	narrow	broad	broad	broad
$Var(\rho_t^{mc})$	col. (3)	model, time	93	77	100	3654
$\frac{Var[E(\rho_t^{mc}\|mc)\|m]}{Var(\rho_t^{mc}\|m)}$		average of ratios	80	66	67	91
$Var(\kappa_t^{mc})$	$Var(\rho_t^{mc})$	country	80	75	76	48
$Var(\tilde{\kappa}_t^{mc})$		country, time	66	64	65	44
$Var(\tilde{\tilde{\kappa}}_t^{mc})$		country, model	18	35	33	5
$Var(\varepsilon_t^{mc})$		country, time, model	13	27	25	3
$Var(\varepsilon_t^{mc})$	col. (3)	country, time, model	47	81	100	491
# observations			36985	32315	41704	40614

Row 1 is based on the residuals ρ_t^{mc} from the regression $P_t^{mc} = \alpha + \alpha_m + \alpha_t + \alpha_{mt} + X_t^{mc} + \rho_t^{mc}$. The dependent variable P_t^{mc} is the pre-tax car price in columns (1), (2), and (3), and the after-tax car price in column (4). In rows 3 to 7 the dependent variable is the respective residual ρ_t^{mc} of the regression in row 1. Rows 3 to 7 are based on the residuals κ_t^{mc}, $\tilde{\kappa}_t^{mc}$, $\tilde{\tilde{\kappa}}_t^{mc}$, and ε_t^{mc} from the following regression specifications. For row 3: $\rho_t^{mc} = \alpha + \alpha_c + \kappa_t^{mc}$. For row 4: $\rho_t^{mc} = \alpha + \alpha_c + \alpha_{ct} + \tilde{\kappa}_t^{mc}$. For row 5: $\rho_t^{mc} = \alpha + \alpha_c + \alpha_{mc} + \tilde{\tilde{\kappa}}_t^{mc}$. For row 6: $\rho_t^{mc} = \alpha + \alpha_c + \alpha_{ct} + \alpha_{mc} + \varepsilon_t^{mc}$. α_c, α_t, α_m, α_{mt}, α_{ct} and α_{mc} denote country, time, model, model-time, country-time, and country-model effects, respectively. X_t^{mc} is the engine power measured in ccm. EU27. The broad model definition in columns (2) to (4) excludes cars with right-hand drive.

Table 3: Time Trends in Price Dispersion

	(1)	(2)	(3)	(4)	(5)
sample period	1993–2011	1993–2003	2000–2011	2000–2011	2000–2008
model definition	broad	broad	broad	narrow	narrow
country sample	EU15	EU15	EU27	EU27	EU27
Time	-0.245***	-1.257***	-0.179***	0.045	0.017
(years)	*(0.063)*	*(0.160)*	*(0.066)*	*(0.097)*	*(0.096)*
Time^2	-0.038***	-0.111***	0.065***	0.030*	0.080***
(years^2)	*(0.006)*	*(0.013)*	*(0.013)*	*(0.017)*	*(0.021)*
EU25	0.235		0.720***	0.690***	0.580**
	(0.218)		*(0.221)*	*(0.255)*	*(0.253)*
EU27	1.487***		0.448***	0.759***	0.301
	(0.202)		*(0.144)*	*(0.278)*	*(0.266)*
Fin. Crisis	3.742***		2.018***	3.497***	
(2009)	*(0.332)*		*(0.258)*	*(0.405)*	
After Crisis	4.068***		0.107	1.237**	
(2010+)	*(0.392)*		*(0.381)*	*(0.577)*	
Car Price	-5.293***	-2.374	-6.257***	-16.276***	-12.242***
(log EUR)	*(1.098)*	*(1.735)*	*(1.205)*	*(2.790)*	*(2.830)*
Extremum	Max 2000	Max 1998	Min 2005	Min 2003	Min 2003
R^2 within	0.15	0.11	0.23	0.28	0.09
# observations	3053	1732	2127	2780	2294

Dependent variable: 100× standard deviation of log pre-tax EUR prices across countries, Ξ_t^m. Fixed effects model (2). R^2 within is based on the mean-deviated regression. Constant and model fixed effects not reported. Bootstrap standard errors in parentheses. Asterisks indicate the level of significance, (*) at the 10%, (**) at the 5%, and (***) at the 1% level.

Table 4: Price Dispersion and Common Currency

	(1)	(2)	(3)	(4)	(5)
sample period	1993–2011	1993–2003	2000–2011	2000–2011	2004–2011
model definition	broad	broad	broad	narrow	narrow
country sample	EU15	EU15	EU25	EU25	EU25
Constant	5.338***	5.587***	4.894***	5.122***	4.038***
	(0.080)	*(0.229)*	*(0.056)*	*(0.087)*	*(0.212)*
Outside Euro Area	5.887***	7.156***	6.860***	6.365***	2.140***
Constant	*(0.451)*	*(0.439)*	*(0.415)*	*(0.427)*	*(0.208)*
Outside Euro Area			-5.233***	-4.702***	
× EU25			*(0.514)*	*(0.532)*	
Time	0.094***	-0.042	0.012	0.147***	0.334***
	(0.032)	*(0.070)*	*(0.028)*	*(0.048)*	*(0.070)*
Outside Euro Area	0.332***	0.590***	0.325***	0.259***	0.126*
× Time	*(0.072)*	*(0.081)*	*(0.068)*	*(0.073)*	*(0.076)*
Since Crisis	1.137***		1.690***	1.529***	1.022***
(2009+)	*(0.139)*		*(0.141)*	*(0.231)*	*(0.264)*
Outside Euro Area	-0.010		-1.377***	-1.333***	-0.813*
× Since Crisis	*(1.877)*		*(0.383)*	*(0.404)*	*(0.429)*
Car Price	-6.754***	-6.128***	-3.813***	-8.129***	-4.927**
(log EUR)	*(0.732)*	*(1.162)*	*(0.660)*	*(1.592)*	*(1.991)*
R^2 within	0.34	0.35	0.43	0.39	0.34
# observations	3278	2069	3294	3723	2703

Dependent variable: 100× standard deviation of log pre-tax EUR prices across countries, Ξ_t^m. Ordinary least squares regression with model fixed effects (3). R^2 within is based on the mean-deviated regression. Model fixed effects not reported. The constant is calculated with the sum of model fixed effects constrained to zero and car prices centered at the respective full-sample mean. Robust standard errors in parentheses. Asterisks indicate the level of significance, (*) at the 10%, (**) at the 5%, and (***) at the 1% level.

Table 5: Determinants of Price Dispersion

		(1)	(2)	(3)	(4)
sample period		1993–2011	2000–2011		
model definition		broad	narrow		
country sample		EU15	EU15	EU15	EU25
Seg-ment	Mini	-4.226***	-4.442***	-4.402***	-3.966***
		(0.663)	*(0.590)*	*(0.601)*	*(0.714)*
	Small	-2.661***	-3.245***	-3.271***	-2.200***
		(0.662)	*(0.526)*	*(0.530)*	*(0.633)*
	Medium	-0.793**	-0.804**	-0.861**	-0.898*
		(0.433)	*(0.381)*	*(0.389)*	*(0.468)*
	Large	0.648*	0.936***	0.875***	0.380
		(0.372)	*(0.308)*	*(0.315)*	*(0.365)*
	Executive	1.085**	1.334***	1.286***	1.495***
		(0.456)	*(0.401)*	*(0.391)*	*(0.428)*
	Luxury	1.412*	0.011	-0.132	0.825
		(0.731)	*(0.421)*	*(0.415)*	*(0.546)*
Engine Power			0.043***	0.034***	0.035***
(kW)			*(0.007)*	*(0.007)*	*(0.008)*
Fuel Type			-0.654***	-0.787***	-0.068
(1 = diesel)			*(0.236)*	*(0.244)*	*(0.308)*
Brand			3.256***	3.145***	1.912
Centrality			*(0.987)*	*(0.996)*	*(1.230)*
Car Price		-4.786***	-7.314***	-6.998***	-7.286***
(log EUR)		*(0.540)*	*(0.728)*	*(0.718)*	*(0.827)*
Dispersion of		2.556***	1.021***	1.056***	0.811***
VAT		*(0.245)*	*(0.212)*	*(0.215)*	*(0.273)*
Fin. Crisis		3.454***	2.485***	-0.421	0.397
(2009)		*(0.311)*	*(0.339)*	*(0.764)*	*(0.834)*
Fin. Crisis ×				0.030***	0.034***
Engine Power				*(0.009)*	*(0.009)*
After Crisis		2.638***	1.136***	-0.658	-1.925**
(2010+)		*(0.361)*	*(0.441)*	*(0.607)*	*(0.902)*
After Crisis ×				0.019***	0.031***
Engine Power				*(0.006)*	*(0.009)*
Time		-0.016	-0.053	-0.048	-0.032
(years)		*(0.033)*	*(0.047)*	*(0.047)*	*(0.064)*
Time^2		0.016***	0.051***	0.051***	0.042***
(years^2)		*(0.004)*	*(0.012)*	*(0.012)*	*(0.012)*
EU25					0.829***
					(0.232)
R^2 within		0.25	0.27	0.30	0.31
R^2 overall		0.41	0.46	0.47	0.28
# observations		3053	2058	2058	2680

Dependent variable: 100× standard deviation of log pre-tax EUR prices, Ξ_t^i, across countries. Constant not reported. Random effects GLS estimation of Equation (4). Bootstrap standard errors in parentheses. Asterisks indicate the level of significance, (*) at the 10%, (**) at the 5%, and (***) at the 1% level.

Table 6: Price Regression

	(1) FE, EU27	(2) RE, EU27	(3) RE, EU27	(4) RE, EU15
Distance to Plant	1.03***	0.01	0.17*	-0.17
(ln km)	*(0.35)*	*(0.11)*	*(0.10)*	*(0.11)*
Brand Centrality		-5.63***	-7.49***	-6.52***
		(1.09)	*(1.04)*	*(1.65)*
Home brand		-0.57	Interacted	-0.77**
(1=domestic)		*(0.42)*	with Country	*(0.39)*
AC	1.28***	0.86***	Interacted	0.76***
(1=standard)	*(0.30)*	*(0.24)*	with Country	*(0.25)*
NO_x	-0.31***	-0.30***	-0.24***	-0.27***
(ratio to seg. median)	*(0.10)*	*(0.10)*	*(0.08)*	*(0.11)*
NO_x if diesel	-0.37	-0.27	-0.21	-0.45
(ratio to seg. median)	*(0.46)*	*(0.45)*	*(0.38)*	*(0.49)*
HC	1.17***	1.09***	1.35***	0.99***
(ratio to seg. median)	*(0.31)*	*(0.31)*	*(0.25)*	*(0.33)*
HC if diesel	-1.05***	-0.92***	-1.32***	-1.04***
(ratio to seg. median)	*(0.32)*	*(0.32)*	*(0.26)*	*(0.34)*
Fuel Consumption	-0.75***	-0.73***	Interacted	-0.75***
(city, l/100km)	*(0.26)*	*(0.26)*	with Country	*(0.29)*
Fuel Consumption	1.77***	1.64***	Interacted	2.12***
(highway, l/100km)	*(0.55)*	*(0.56)*	with Country	*(0.60)*
Fuel Type			Interacted	
(1=diesel)			with Country	
Registration Tax	-0.17***	-0.11***	Interacted	-0.09***
(%)	*(0.02)*	*(0.01)*	with Country	*(0.01)*
VAT	11.05***	9.26***		17.96***
(%)	*(1.25)*	*(0.97)*		*(1.52)*
VAT^2	-0.25***	-0.21***		-0.45***
($\%^2$)	*(0.03)*	*(0.02)*		*(0.04)*
Population	22.26***	40.02***		57.86***
(ln)	*(6.17)*	*(3.51)*		*(4.40)*
GDP p.c.	9.96***	9.21***		12.41***
(ln EUR @ PPP)	*(1.98)*	*(1.35)*		*(2.39)*
Country, Model, Time Effects	Yes	Yes	Yes	Yes
Country×Time Effects	No	No	Yes	No
R^2 within	0.21	0.21	0.44	0.25
R^2 overall	0.99	0.98	0.99	0.98
# observations	28149	28149	28149	20438

Dependent variable: Log points of pre-tax EUR prices, p_t^{mc}. Estimation equation (5) for FE, and (6) for RE. Narrow model definition, 2000–2011. Constant and fixed effects are not reported. Further controls which are not statistically significant: euro area, particle emissions, warranty, bundled ABS, bundled airbag. Standard errors clustered at the model-country level in parentheses. Asterisks indicate the level of significance, (*) at the 10%, (**) at the 5%, and (***) at the 1% level.

Table 7: Home Brand Effect

France	5.02***
	(0.44)
Czech Republic	4.38***
	(1.45)
Italy	4.16***
	(0.80)
Germany	-1.63***
	(0.50)
Sweden	-3.65***
	(0.75)
United Kingdom	-6.25***
	(1.55)

Coefficient λ from column (3) of Table 6. Brands are assigned to home countries as follows: Peugeot, Renault, and Citroen (France); Fiat and Alfa Romeo (Italy); Audi, BMW, Mercedes-Benz, Opel, and Volkswagen (Germany); Skoda (Czech Republic), Volvo and Saab (Sweden); MG Rover, Land Rover, and Mini (UK).

Table 8: AC Bundle Pricing and Climate

Max. Temperature × Cool Country	0.71***
	(0.18)
Max. Temperature × Hot Country	0.93***
	(0.21)
Hot Country	-13.43*
	(7.63)
Constant	-14.33***
	(4.02)

Dependent variable: Coefficients on AC bundle from column (3) of Table (6). Hot countries have an average maximum temperature in the hottest month of at least 27 degrees Celsius. 27 observations. Adj. $R^2 = 0.57$.

Table 9: LCU Price Changes and the Business Cycle

Percentage Change in	(1) FE	(2) FE	(3) FE	(4) FE, IV
LCU/EUR	-0.098***	-0.098**	-0.099**	-0.254**
(survey period)	*(0.036)*	*(0.038)*	*(0.040)*	*(0.120)*
domestic		-0.003		
cars		*(0.075)*		
LCU/EUR	0.105***	0.118***	0.103***	0.299**
(two years)	*(0.026)*	*(0.028)*	*(0.037)*	*(0.150)*
domestic		-0.105*		
cars		*(0.059)*		
GDP p.c. @PPP	0.025	0.025	0.026	0.062*
	(0.016)	*(0.016)*	*(0.020)*	*(0.033)*
Bundling of AC			0.013***	
			(0.003)	
# obs.	17269	17269	17118	17123

Dependent variable: Rate of change in pre-tax LCU price. Fixed effects regression. In column (4) LCU/EUR (two years) is instrumented by the real GDP growth rates in the current and past year and by the other independent variables. Constant and fixed effects are not reported. Bootstrap standard errors in parentheses. Narrow model definition, EU 15, 2000–2011. Asterisks indicate the level of significance, (*) at the 10%, (**) at the 5%, and (***) at the 1% level. LCU/EUR (survey period) is the rate of change since the most recent car price survey in the exchange rate. LCU/EUR (two years) is the rate of change during the past two years in the exchange rate. The exchange rate is measured in units of local currency per euro. GDP p.c. is the year-over-year growth rate of per-capita GDP, measured in euros at purchasing power parity, during the calendar year before the survey.

Table 10: Price Changes during 2008

		(1)	(2)	(3)	(4)
		Member of euro area			
		no		yes	overall
		EUR	LCU	EUR	EUR
Domestic Production	no	-0.038	0.009	0.016	-0.008
	yes	-0.152	-0.023	0.011	-0.056
	overall	-0.042	0.008	0.016	-0.010

Change in pre-tax EUR car price from January 2008 to January 2009. Countries equally weighted. Narrow model definition, for all EU 27 countries available.

A Data Appendix

In this appendix we describe the main steps of assembling our dataset from the original data sources. We first describe the cleaning of the EC price data, then the matching with the UK technical dataset and the construction of brand perception data. In the end, we report some summary statistics.

A.1 Cleaning Car Price Data

In this section we describe our procedure to standardize and clean the EC price data in more detail.

The data is provided online via tables in portable document format (PDF). To make it accessible to quantitative analysis, we convert these tables into Stata format and subject the data to an extensive cleaning. Since our analysis hinges on the availability and pricing of features and installed options, we painstakingly search for input errors, inconsistent measurement units, and the like. The cleaning proceeds in the following sequence:

1. We manually reformat all prices to a common numerical convention, e.g. a period denoting the decimal separator.

2. We convert all prices to euro using the exchange rate at the date of the respective report. Likewise, we convert technical information to common units across countries.

3. We create dummy variables for the options. A value of one signifies that the appropriate option is reported as standard for the model in a particular country. A value of zero signifies that the option is either unavailable for that model-country combination, or that a price is given for that option. A missing value signifies that we cannot determine whether the option was offered or not.

4. We drop an observation if clearly wrong. Examples include: an unreasonably high or low price, a pre-tax price which is higher than the after-tax price, or instances where the prices reported were clearly copied from adjacent columns by mistake.

5. In some cases we are able to insert a data point. A typical case for this is where a pre-tax price is not reported, but the after-tax price is. Exploiting the cross section (other models of the same manufacturer in the same period) as well as the time series (same model in other periods), we are often able to insert the missing data with confidence.

6. We double-check the accuracy of pre-tax prices using taxation manuals published by PricewaterhouseCoopers (2011). Because of large reporting errors for the Seat brand, we exclude Seat models from the analysis.

A.2 Matching with UK Technical Data

The original EC car price data contains a short verbal description of the car model, intended to identify the specific car. This information contains the brand and model name, and usually a combination of information on engine capacity, engine power, and sometimes other car features. We translate this verbal information into numbers. We also use it to assign a fuel type to each car based on publicly available model lineups. If the available verbal car information matches both petrol and diesel versions, then no fuel type is assigned.

The raw technical dataset provided by the UK Royal Certification Agency (RCA) contains multiple test results for the same model. These stem from at least three sources: First, some are duplicate records of a single measurement, sometimes with rounding at different precision, which we replace by the most precise observation. Second, some are separate measurements obtained from different cars with identical specifications, which we replace by the average of the measured values. Third, some are obtained from different cars which differ by characteristics not recorded in the EC car price data set, e.g. by tire size. In this case we pick the car with the most common characteristics, for example in the case of tire size the observation with a tire diameter closest to 16 inch. After this cleaning, each model is uniquely identified by brand, model name, engine capacity, engine power, fuel type, transmission, and number of doors. If a specific combination of these characteristics is not listed in a given period, we assume that a listed combination existed up to two periods before and up to three periods after its first appearance in the technical dataset as well.

[Table 11 about here.]

The RCA technical dataset starts in the year 2000, so that up to 40776 observations from the EC price data could potentially be matched. The actual number of matches is smaller for two reasons. First, the RCA data does not contain the brand Lancia, which the EC price data does. Second, the EC price data contains car versions that have never been sold and thus never been tested in the UK. The prime example are uncommon engine specifications, in combination with differences in transmission. The merge between the two datasets proceeds in four steps. First, we match based on time, brand, model name, engine capacity, engine power, fuel type, transmission, and number of doors (7% of observations). Second, we match based on time, brand, model name, engine capacity, engine power, fuel type, transmission (29% of observations). Third, we match based on time, brand, model name, engine capacity, fuel type and transmission if the engine power information is missing in either dataset (52% of observations). As broken down in Table 11, in total we are able to assign technical information to 88% of all observations after the year 2000, and to 92% of all observations excluding the brands Jaguar, Lancia, and Seat. In 79% of matches the periods of the EC and UK dataset coincide, and in another 15% of matches they are offset by one period.

A.3 Construction of Brand Perception Data

The basis of the brand centrality and proximity measures are the Google search statistics available at Google Insights (`http://www.google.com/insights/search/#`). We are using the information of search terms that were entered simultaneously with any given car brand in our sample.

We extracted the statistics on "Web Search" in "all categories" for the time period "2004-present" from the list of "Top searches" available after logging into a Google account. The search terms, submitted in UTF-8 encoding were: '"alfa romeo"', 'audi', 'bmw', 'citroen + CITROËN', 'daihatsu', 'fiat', 'ford', 'honda', 'hyundai', 'kia', 'lancia', '"land rover"', 'mazda', 'mercedes + benz + daimler + "Mercedes-Benz"', 'rover + "land rover"', 'mini + cooper', 'mitsubishi', 'nissan', 'opel + vauxhall', 'peugeot', 'renault', 'saab', 'seat', 'skoda + ŠKODA', 'subaru', 'suzuki', 'toyota', 'volkswagen + vw', 'volvo'. The data set was downloaded, separately for each country in our sample, in multiple sessions between August 13$^{\text{th}}$, 2011 and August 19$^{\text{th}}$, 2011. Search results in Greek and Russian characters where transformed into ANSI coding and then translated. Terms in Bulgarian and Hungarian were examined by native speakers.

According to Google, the reported data are not exact, but approximations. The data was scaled and truncated from below at an unpublished number of searches, leading to shorter brand lists in smaller countries.

From this initial list of co-search terms we extract the ones that refer to other brands in our sample. In the case of double appearances of a given brand we use the maximum. In the case of "Toyota" in Ireland, for example, "Ford" shows up once as "Ford (15)" and once as "Ford Ireland (5)". We therefore use "15" as the joint search intensity of Ford and Toyota.

Maintaining the example of "Toyota" in Ireland, a search in all years returns the cobrands: Ford 15+5, Nissan 15+5, Honda 10, Volkswagen 5, BMW 5, Mitsubishi 5, and Hyundai 5.

We summarize this information in a brand proximity matrix Ψ_c for each country, with the value "100" on the diagonal, and zeros for brand pairs with no information on Google Insights. We convert this matrix into the symmetric matrix $S_c = v_c \Psi_c' \Psi_c v_c$, where v_c is the inverse of the Cholesky decomposition of the matrix obtained by setting all off-diagonal elements of $\Psi_c' \Psi_c$ to zero.

Our measure of brand centrality for a given brand in a given country c is the corresponding element of the Eigenvector of the largest Eigenvalue of matrix S_c. Using the largest Eigenvalue also guarantees that all elements of the Eigenvector are positive.

A.4 Summary Statistics

After excluding the brands Jaguar, Lancia and Seat, we obtain the final dataset described in Table 12. The coverage increases over time with the EU enlargement rounds until the dataset covers 27 brands in 27 EU countries. The 1993–1999 subsample distinguishes 115 models, 70 of which have an exact counterpart in the 2000–2011 subsample. Considering the gearbox type besides the model name and excluding right-hand drive cars, the set of cars during 2000–2011 can be divided into 260 distinct (broad) specifications. Because we do not have gearbox information until the year 2000, we classify observations before and after January 2000 as separate specifications. Considering the entire car specification data available, i.e. additionally engine size, engine power, fuel type, number of gears, euronorm, number of doors, and a right-hand drive indicator, we can distinguish 1537 (narrow) specifications during 2000–2011.

[Table 12 about here.]

Table 13 reports summary statistics for the full sample under the broad model definition, i.e. excluding right-hand drive cars. The dataset covers the entire car spectrum, with pre-tax price tags ranging from less than 4000 EUR up to well above 80000 EUR. Similarly, engine sizes range from less than one litre up to four litres and more. The median car price in our sample increases considerably during the sample period, from less then 13000 EUR in the early to more than 17500 EUR in the later subsample. The sampled price range spreads out at both ends. At the same time, the median engine size increased from 1600 ccm to almost 1800 ccm. This increase is engine size is also reflected in larger minimum and maximum engine sizes.

[Table 13 about here.]

B Additional Results and Robustness Checks

B.1 Frequency Distribution of Model-Specific Real Exchange Rates (alternative samples)

[Figure 7 about here.]

B.2 Price Dispersion over Time

The dispersion of P_t^{imc}, i.e. the dispersion without taking the natural logarithm of prices, in Figure 8 shows that same pattern as Figure 2: A decline in dispersion until 2004, a period of constant dispersion in the mid-2000, and a jump in dispersion at the onset of the financial crisis.

[Figure 8 about here.]

Figure 9 confirms that in the 1990s price differences of 40 percent among EU15 countries were common. In the mid-2000s prices the difference between the maximum and the minimum price of a given model across EU15 countries shrunk to about 20 percent, and jumped up to about 30 percent in the financial crisis.

[Figure 9 about here.]

Table 14 redoes the analysis of Table 5, restricting the sample to the most common models. Here we only consider the dispersion of log pre-tax EUR prices, Ξ_t^i, across countries for models available in at least ten countries at a given time.

[Table 14 about here.]

B.3 Country-Specific Time Trends

[Figure 10 about here.]

Throughout Europe car prices increased by about two percent per year during 2000–2011. As Figure 10 shows, this monotone upward trend was broken by the financial crisis in the Czech Republic, Malta, Poland, Sweden, Slovakia, and the UK. The UK is the only country in the sample with clearly falling car prices during the sample period.

B.4 Brand, Country, and Segment Effects

In this section we show results from a random effects specification analogous to column (3) in Table 6, with model fixed effects α_m replaced by 6 (7-1 base) segment effects $\alpha_{s(m)}$ and 27 (28-1 base) brand effects $\alpha_{b(m)}$.

[Table 15 about here.]

Unsurprisingly, there remains a significant segment premium even after controlling for observable car features (Table 15). The reason might car features not captured by our dataset, as well as a cars usefulness as status symbol.

[Table 16 about here.]

The ordering of brand effects presented in Table 16 is strikingly intuitive. For a car with identical features and options, the price of a Mini is more than double the price of a Suzuki. At the same time, about one third of the brands in the center of the distribution charge very similar prices, all else equal.

[Table 17 about here.]

Table 17 confirms the large variation of prices across countries. It is fairly close to the variation across brands shown in Table 16. The ceteris paribus most expensive countries in 2011 were Sweden and Germany, the cheapest Cyprus and Greece. The ordering of countries changed only modestly between 2004 and 2011. The most notable relative changes are relative price decreases in Ireland and the UK, and a relative price increase in Estonia.

B.5 Availability of Models

This paper compares only mechanically identical cars. Table 18 shows the diversity of technical specifications that we control for, i.e. how dissimilar cars offered to European consumers are. Countries with driving on the left share by construction very few models with the rest of Europe, because the standard car differs in the position of the steering wheel. These differences in technical properties increase the dispersion of headline car prices further, but such dispersion should not be seen as LOP deviation because the underlying products are technically different. Different marketing of products, e.g. by including AC, does not establish a separate model, but creates another dimension of differentiation (Table 1).

[Table 18 about here.]

C Changes in Regulation of the EU Car Market

This appendix gives a short overview of the the regulatory environment relevant to our data. Since the late 1990s, the regulatory framework of the European new car market has radically changed. The most relevant regulations for the new car market during our sample period are

- 2002: EU Consumer Goods Directive (European Commission, 1999): EU-wide two-year warranty, incl. used cars (Commission Directive 1999/44/EC),
- 2002: Block Exemption Regulation (European Commission, 2002): Delayed unbundling of sales, service, and warranty (Commission Regulation 1400/2002),
- 2005: Car Registration Directive (European Commission, 2004): Introduction of a Europe-wide car registration documents (Commission Directive 2003/127/EC amending 1999/37/EC)
- 2007: Framework Directive (European Commission, 2007): Harmonizing laws for EU-wide type approval (Commission Directive 2007/46/EC replacing 70/156/EEC)

The European Commission's (EC) interest in the evolution of price dispersion in the car market stems from the need to design block exemption regulations for the car market. These block exemption regulations exempt certain agreements between manufacturers and downstream dealers and repair shops from the EU ban on restrictive business practices, in particular from Article 101(1) of the Treaty on the Functioning of the European Union. This is in contrast to other consumer goods markets, where any "prevention, restriction or distortion of competition within the internal market" is prohibited (Article 101(1) of the Treaty). Replacing the principles of Article 101(1) without giving up competition in the new car market completely requires a large set of rules tailored to the car market, which are collected in the block exemption regulation. The block exemption regulation grants the car industry special rights, for example to determine how and by whom their new cars can be sold, as long as certain conditions are met.

Conditions, which the 2002 block exemption regulation (European Commission, 2002) specifies, are among others:

- Manufacturers must choose between selective and exclusive distribution; i.e. either the manufacturer assigns regions to sellers, but permits resale by third-party dealers, or he selects dealers without assigning regions, but prohibits all sales to third-party dealers.
- Manufacturers cannot prohibit the dealer to sell cars of other brands in the same location.

- Manufacturers cannot force dealers to operate a repair shop; independent repair shops get better access to OEM spare parts, tools, and technical information; spare parts can be obtained directly from its manufacturer, not necessarily the car maker

- Manufacturers cannot impose "restrictions impeding dealers in one Member State to sell vehicles with specifications pertaining to another Member State (e.g. right-hand drive cars)" (European Commission DG-COMP, 2002, p.13).

Despite these conditions, manufacturers have many levers to restrict new car trade across intra-European borders. For example, they can prohibit sales from authorized dealers to resellers. Due to these restrictions, there are only few dealers selling cars Europe-wide. The European car reimport market is dominated by car brokers, who have to obtain documentation from their customers to prove the "end-consumer status" to the manufacturer or brand dealership.

The framework directive (European Commission, 2007) defines safety and environmental requirements that must be met by cars sold in the EU. The certification, documented by a "certificate of conformity", is the responsibility of national authorities. Even under the preceding directive, right-hand-drive and left-hand-drive can be operated throughout the EU.

The eagerness of the EC to further liberalize the European new passenger car market seems to have been limited. In its 2009 report it states: "The Commission's third objective was to encourage intra-brand competition across borders. The objective appears to have been achieved, as prices between Member States have converged and cases of hindrances to parallel trade, including complaints from final consumers, have significantly diminished."(European Commission, 2009, p.6)

A new block exemption regulation (European Commission, 2010) went into effect on June 1^{st} 2010 for the markets for repair, maintenance and spare parts. The new regulations on the purchase, sale or resale of new motor vehicles replaced European Commission (2002) starting June 1^{st} 2013, and are thus not relevant for our sample period. Nevertheless, the changes of the new block exemption regulation showcase where – in the EC's point of view – competition was most severely constrained during the sample period. In particular, the new regulation:

- prohibits discrimination by manufacturers of independent repair shops in obtaining technical information and spare parts, if the manufacturer's repair shop network has above 30% market share.
- prohibits conditioning manufacturer warranty on the car being serviced (oil changes, etc.) at manufacturer-authorized garages only. However, repairs covered by the warranty can

still be restricted to the manufacturer-authorized network.

- lifts some restrictions on manufacturers imposed by European Commission (2002): Under certain conditions, manufacturers are again allowed to require single-brand showrooms. This is supposed to reduce distribution costs which are claimed to have increased due to European Commission (2002) because manufactures increased the investments required from the dealers to ensure a unique and separate brand presentation.

Clearly, even under the new regulation car manufacturers will have opportunities to limit cross-country new car trade.

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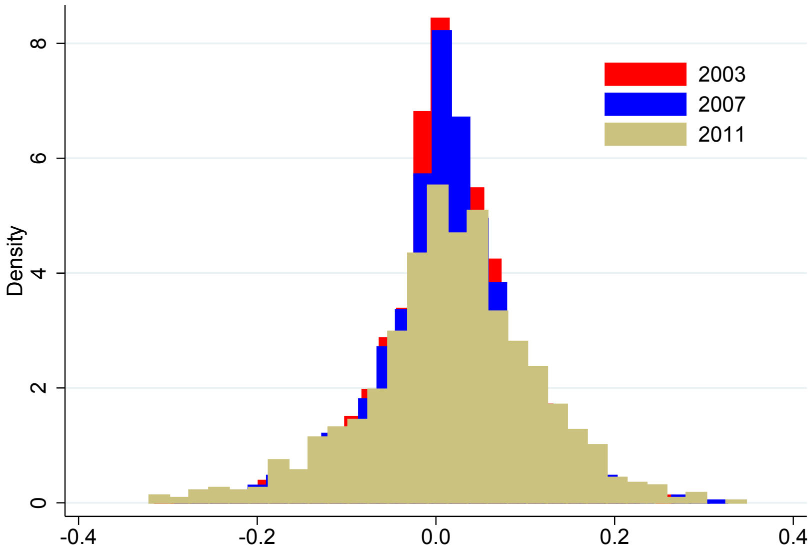
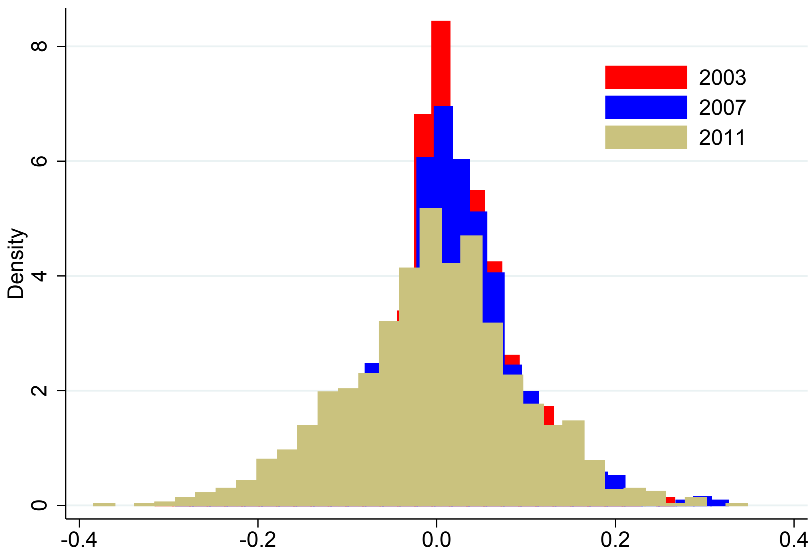
Figure 7: Frequency Distribution of Model-Specific Real Exchange Rates 2003-2011

(a) EU15

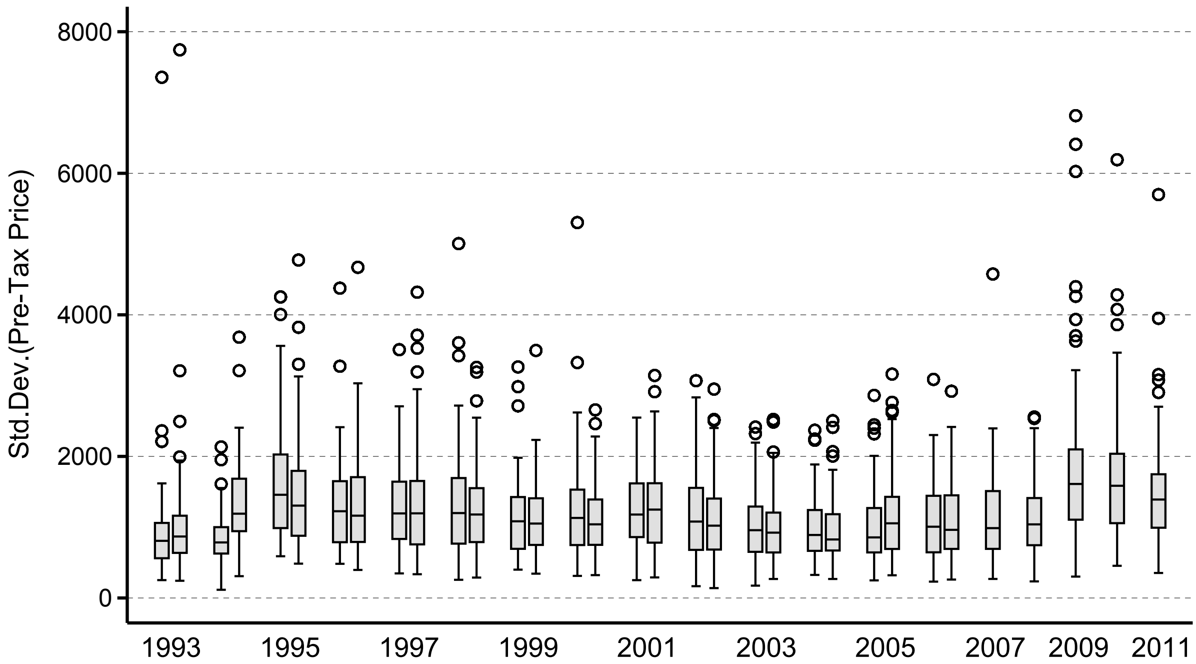


(b) EU25



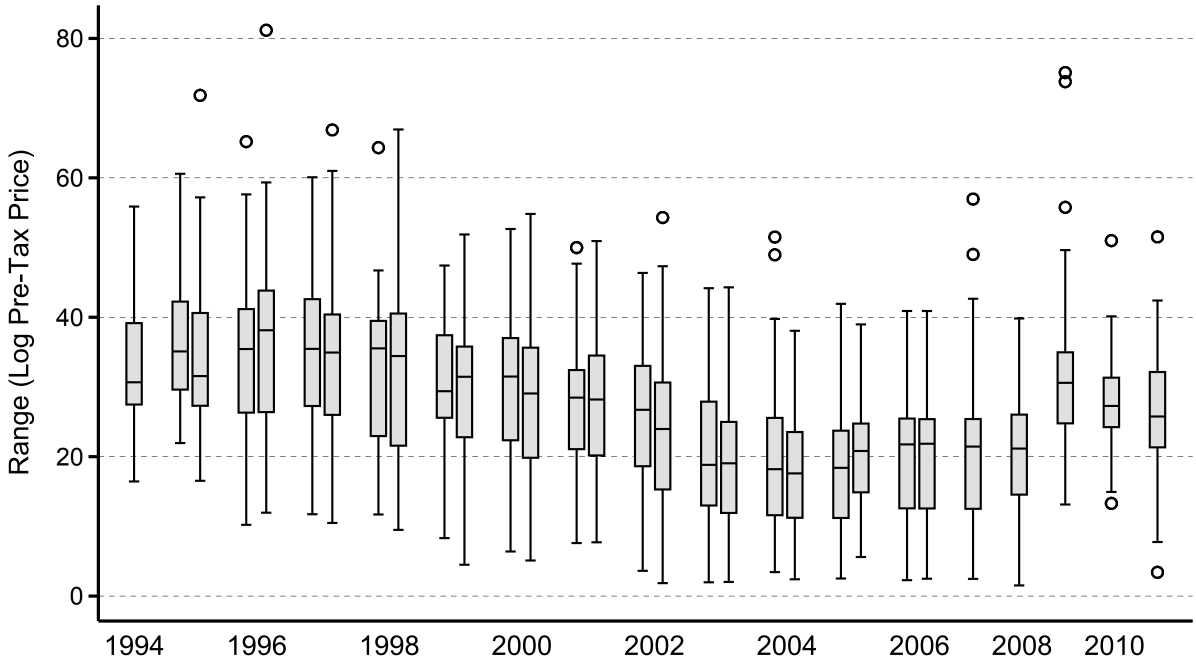
The histogram shows the frequency distribution of model-specific real exchange rates, r_t^{mc}, for the months November 2003, May 2007 and January 2011. Narrow model definition. The upper panel covers prices in the EU15 countries only, whereas the lower panel covers the EU25 countries.

Figure 8: Price Dispersion



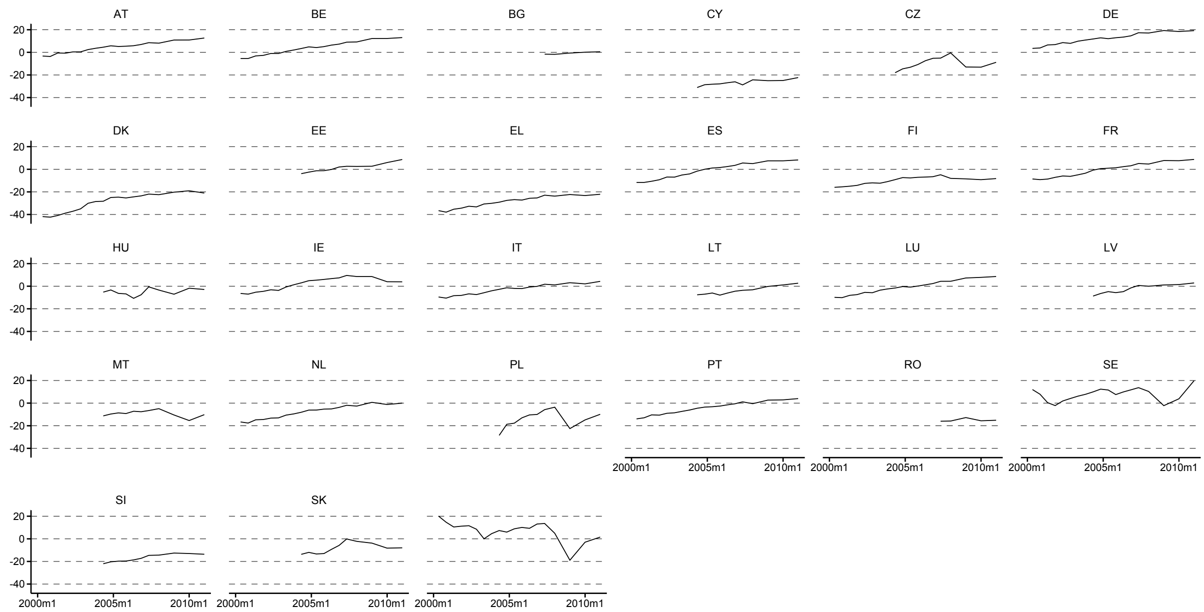
The graph shows the distribution across models of the model-specific cross-country dispersion of prices, P_t^{mc}. Broad model definition. EU 15 countries only. Boxes represent the 25^{th}–75^{th} percentile range, with the horizontal line denoting the median. The lower whisker ends at the "largest observed value below the 25^{th} percentile minus 1.5 interquartile ranges" threshold, and the upper whisker ends at the "smallest observed value above the 75^{th} percentile plus 1.5 interquartile ranges" threshold. Circles represent outliers.

Figure 9: Price Range



The graph shows the distribution across models of price ranges (difference between maximum and minimum price of a given model across countries) of the log price p_t^{mc}. Broad model definition. EU 15 countries only. Only models available in at least 10 countries. Boxes represent the 25th–75th percentile range, with the horizontal line denoting the median. The lower whisker ends at the "largest observed value below the 25th percentile minus 1.5 interquartile ranges" threshold, and the upper whisker ends at the "smallest observed value above the 75th percentile plus 1.5 interquartile ranges" threshold. Circles represent outliers.

Figure 10: Time Trends in Prices, 2000–2011



The graph shows the country-specific time trends in prices given by the country-time effects from column 3 in Table 6.

Table 11: Construction of Dataset

period	EC data all	EC-RCA matches	excl. Jaguar, Lancia, Seat all	matches
1993–1999	12655	0	11573	0
2000–2011	40776	35974	37348	34456
1993–2011	53431	35974	48921	34456

Table 12: Dataset Summary

period	1993 –1999	2000 –2011	1993 –2011
# countries	15	27	27
# brands	22	27	27
# models	115	159	204
# broad specs	115	260	375
(# observations)	(9863)	(32630)	(42493)
# narrow specs	-	1537	-
(# observations)	(11573)	(37348)	(48921)

Under broad model definition the 6428 right-hand drive observations are excluded. Restricting the sample to EU 15 countries, the number of broad specifications shrinks to 255 (24274 observations) and the number of narrow specifications to 1503 (27844 observations) in the period 2000–2011.

Table 13: Summary Statistics

	period	1993 –1999	2000 –2011	1993 –2011
pre-tax	minimum	4518	3949	3949
price	median	12874	17717	16414
(EUR)	maximum	65421	80924	80924
engine	minimum	899	954	899
size	median	1600	1796	1783
(ccm)	maximum	3947	4367	4367

Broad model definition, excluding right-hand drive models. Restricting the sample to EU 15 countries changes median values only slightly. The median pre-tax price during 1993–2011, for example, falls to 16003 EUR.

Table 14: Determinants of Price Dispersion

	(1)	(2)	(3)	(4)
sample period	1993–2011		2000–2011	
model definition	broad		narrow	
country sample	EU15	EU15	EU15	EU25
Time	-0.054	-0.094*	-0.090*	-0.168***
(years)	*(0.036)*	*(0.049)*	*(0.048)*	*(0.062)*
Time^2	0.032***	0.067***	0.068***	0.070***
(years^2)	*(0.005)*	*(0.012)*	*(0.012)*	*(0.011)*
EU25				0.740***
				(0.234)
Car Price	-4.635***	-6.955***	-6.602***	-6.240***
(log EUR)	*(0.558)*	*(0.755)*	*(0.708)*	*(0.641)*
Segment A	-4.343***	-4.740***	-4.620***	-4.127***
	(0.692)	*(0.605)*	*(0.593)*	*(0.548)*
B	-2.352***	-3.261***	-3.262***	-2.758***
	(0.695)	*(0.554)*	*(0.546)*	*(0.488)*
C	-0.549	-0.752**	-0.793**	-0.500
	(0.463)	*(0.394)*	*(0.388)*	*(0.361)*
D	0.789*	0.949***	0.888***	0.916***
	(0.411)	*(0.323)*	*(0.324)*	*(0.296)*
E	1.133**	1.187***	1.129***	1.419***
	(0.502)	*(0.396)*	*(0.386)*	*(0.362)*
F	0.738	-0.158	-0.308	0.118
	(0.519)	*(0.427)*	*(0.418)*	*(0.407)*
Dispersion of	1.469***	0.890***	0.938***	0.209
VAT	*(0.336)*	*(0.278)*	*(0.277)*	*(0.239)*
Avg. Brand		3.640***	3.578***	5.110***
Centrality		*(0.961)*	*(0.965)*	*(0.967)*
Fuel Type		-0.854***	-0.995***	-0.613***
(1 = diesel)		*(0.239)*	*(0.242)*	*(0.228)*
Engine Power		0.039***	0.030***	0.031***
(kW)		*(0.007)*	*(0.006)*	*(0.006)*
Fin. Crisis	3.114***	2.396***	-0.609	0.593
(2009)	*(0.326)*	*(0.369)*	*(0.822)*	*(0.553)*
Fin. Crisis ×			0.030***	0.017***
Engine Power			*(0.009)*	*(0.006)*
After Crisis	1.846***	0.654***	-1.148*	-0.151
(2010+)	*(0.344)*	*(0.446)*	*(0.689)*	*(0.494)*
After Crisis ×			0.019***	0.004
Engine Power			*(0.007)*	*(0.005)*
R^2 within	0.22	0.27	0.30	0.30
R^2 overall	0.47	0.50	0.51	0.50
# observations	2559	1824	1824	1877

Dependent variable: 100× standard deviation of log pre-tax EUR prices, Ξ_t^i, across countries for models that are available in at least ten countries at a given time. Constant not reported. Random effects GLS estimation of Equation (4). Bootstrap standard errors in parentheses. Asterisks indicate the level of significance, (*) at the 10%, (**) at the 5%, and (***) at the 1% level.

Table 15: Car Segment Effects

Mini	-67.25***
	(1.35)
Small	-56.64***
	(1.06)
Medium	-34.06***
	(0.86)
Large	-13.29***
	(0.77)
Executive	1.77**
	(0.80)
Luxury	33.30***
	(1.14)

Segment effects from a random effects specification analogous to column (3) in Table 6, with model fixed effects replaced by segment and brand fixed effects. The omitted category is the multipurpose segment. EU27, narrow model definition, 2000–2011.

Table 16: Brand Effects

Mini	32.72***
Bmw	29.31***
Mercedes-Benz	28.59***
Saab	26.75***
Audi	14.58***
Subaru	10.23***
Land Rover	7.38***
Alfa Romeo	7.24***
Honda	4.52***
Toyota	0
Volvo	-0.96
Renault	-1.13
Citroen	-1.24
Mitsubishi	-1.72
Mazda	-3.90***
Peugeot	-3.99***
Nissan	-5.57***
Opel	-5.86***
Ford	-6.07***
Volkswagen	-8.56***
Fiat	-9.72***
Kia	-9.94***
Hyundai	-10.91***
MG Rover	-13.69***
Skoda	-20.54***
Daihatsu	-29.43***
Suzuki	-30.17***

Brand effects from a random effects specification analogous to column (3) in Table 6, with model fixed effects replaced by segment and brand fixed effects. The omitted category is the brand Toyota. EU27, narrow model definition, 2000–2011.

Table 17: Country Effects

Country	May 2004	Jan 2011
Sweden	9.94***	19.88***
Germany	11.83***	19.21***
Belgium	3.40	13.10***
Austria	4.59**	12.69***
France	-0.74	8.73***
Estonia	-3.88	8.66**
Luxembourg	-1.58	8.60***
Spain	-1.62	8.24***
Italy	-2.76	4.29*
Portugal	-4.52**	4.01**
Ireland	2.94	3.92
Latvia	-8.70*	2.90
Lithuania	-7.57	2.66
UK	7.35	1.58
Bulgaria		0.54
Netherlands	-8.09***	0
Hungary	-5.21*	-2.89
Slovakia	-13.71***	-7.90**
Finland	-9.16***	-8.22***
Czech Rep.	-18.00***	-8.79***
Poland	-28.49***	-9.84***
Malta	-11.28*	-10.17*
Slovenia	-22.01***	-13.64***
Romania		-15.14***
Denmark	-28.28***	-21.01***
Greece	-29.11***	-22.07***
Cyprus	-31.08***	-22.29***

Country-time effects from the random effects specification of column (3) in Table 6. The omitted category is the Netherlands in January 2011. EU27, narrow model definition, 2000–2011.

Table 18: Common Car Models

Number of Countries	May 2000	May 2004	January 2011
1	26	19	31
2	80	50	37
3	1	19	28
4	1	31	36
5	4	3	0
6	6	0	1
7	4	1	0
8	0	2	1
9	5	4	5
10	7	1	0
11	15	2	2
12	15	3	1
13	46	6	3
14	0	2	3
15	0	8	1
16		6	5
17		3	2
18		1	5
19		15	3
20		13	8
21		35	11
22		8	16
23		1	34
24		0	2
25		0	1
26			0
27			0
total	210	233	236

Number of countries for which a given model (narrow definition) is reported in the EC dataset. The horizontal lines mark the number of EU members in the respective period, 15 in the year 2000, 25 in the year 2004, and 27 in the year 2011.

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