Demand Estimation and Merger Simulation in the European Car Market

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1. Summary statistics of the car market

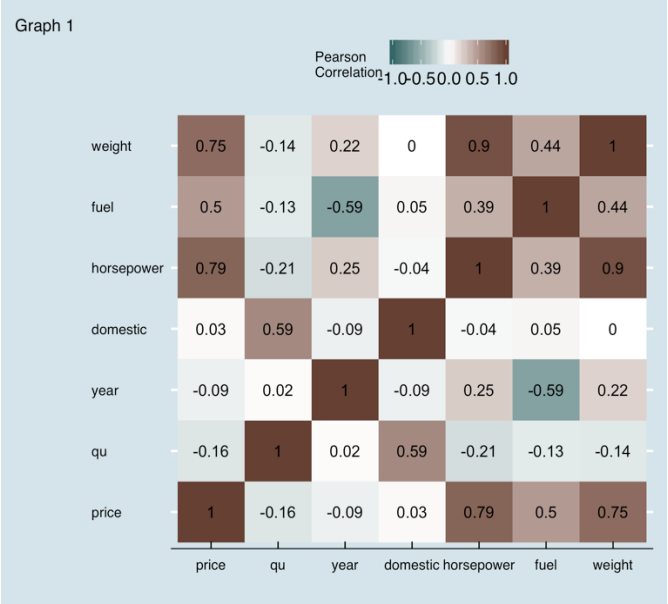
Table 1 shows summary statistics for the five EU countries both collectively and individually, averaging across the 1970-99 timespan. For car-specific variables we have weighted the car-model-year observations by their respective quantity sold. Most striking is a general preference for domestically produced cars where the option exists, suggesting that each producer faces very different competitive conditions domestically vs abroad. Outside Belgium, which produces no cars, the domestic share of consumption ranges from 59% in Italy to Germany's 72%.

Interestingly, the UK average car price is unusually high, at €20,494 compared to a Europe average of €14,549: a 35-50% premium over prices elsewhere. This is not accounted for by other observed physical car characteristics. A potential explanation could be the cost of adapting production to driving on the left-hand side of the road. Generally, Italy and France favour cars of low weight, low horsepower, and high fuel efficiency (these three variables are highly correlated), while German tastes are the opposite, leaning more towards luxury. (Since *segment* is an ordinal variable, our weighted averages are merely illustrative.) Belgian and British tastes lean somewhat towards the German end. These taste differences generally map onto the cross-country distribution of average purchase prices, ignoring the British anomaly. Physical characteristics are clearly relevant to our inquiry since they are obvious determinants of input costs and, through consumer tastes, demand. The same rationale applies to whether a brand is domestic or not.

Table 1: Descriptive statistics

	Entire data frame			Grouped by country				
Variable	All	Min.	Max.	Belgium	France	Germany	Italy	UK
Population (in millions)	48.06	9.66	82.06	9.92	55.36	68.47	56.59	57
	(0.2)			(0)	(0.05)	(0.2)	(0.02)	(0.02)
Domestic	0.5	0	1	0	0.69	0.72	0.57	0.59
	(0.01)			(0)	(0.04)	(0.04)	(0.04)	(0.03)
Price (1000 Euros 1999)	15.73	5.26	150	14.66	14.02	15.29	14.17	20.49
	(0.22)			(0.32)	(0.45)	(0.54)	(0.49)	(0.6)
Price/income	0.7	0.24	6.47	0.64	0.61	0.64	0.74	0.88
	(0.01)			(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
Quantity	19911	51	433694	3965.79	23430.26	31026.37	24345	19858.63
	(352.78)			(86.88)	(804.23)	(1053.14)	(1019.43)	(625.7)
Segment (ordinal)	2.18	1	5	2.31	1.95	2.63	1.73	2.19
	(0.03)			(0.05)	(0.06)	(0.1)	(0.05)	(0.07)
Fuel efficiency	6.32	3.8	18.6	6.48	6.19	6.6	5.94	6.35
	(0.09)			(0.14)	(0.21)	(0.23)	(0.23)	(0.2)
Horsepower	47.82	13	170	48.87	44.63	52.41	42.99	49.42
	(0.64)			(1.03)	(1.42)	(1.79)	(1.49)	(1.43)
Height	140.33	118	174	140.32	141.01	140.79	140.43	139.14
	(2.03)			(3.08)	(4.83)	(4.81)	(5.9)	(4.35)
Weight	917.96	520	1910	931.2	891.57	980.74	846.68	929
	(12.77)			(20.26)	(29.08)	(33.92)	(31.69)	(28.53)
Width	163.42	122	188	164.21	162.24	166.49	159.23	164.3
	(2.35)			(3.61)	(5.51)	(5.7)	(6.51)	(5.18)

Note: Standard errors in parenthesis



2. Determinants of car prices: A hedonic overview

Columns 1 and 2 of Table 2 show a price regression (simple OLS and model fixed effects respectively), with car characteristics as explanatory variables. We note that cars have got cheaper over time, averaging at minus 1 percent per year according to our preferred specification with car model fixed effects. We note that every single variable achieves 1% statistical significance except *domestic* in the simple OLS and *height* in the fixed effects models. This could be a result of overspecification (R^2 = 0.899 and 0.946).

When controlling for model fixed effects, variation still remains in variables such as weight, width and horsepower (car models are sometimes

Table 2: Regressions

	Dependent variable:					
	log(price)		log(market share) - log(outside good market share)			
	Hedonic		Logit		Nested logit	
	Baseline	Model F.E	Baseline	Model F.E	Baseline	Model F.E
price			−0.011***	−0.052***	−0.048***	−0.049***
			(0.003)	(0.003)	(0.001)	(0.001)
ln_mshare_s					0.851***	0.868***
					(0.004)	(0.004)
year	−0.021***	−0.013***	0.002	−0.050***	0.010***	−0.001
	(0.0003)	(0.0004)	(0.002)	(0.003)	(0.001)	(0.001)
horsepower	0.010***	0.007***	−0.036***	−0.012***	−0.003***	0.004***
	(0.0001)	(0.0002)	(0.001)	(0.001)	(0.001)	(0.001)
fuel	−0.029***	−0.013***	−0.065***	−0.068***	0.004	−0.023***
	(0.001)	(0.001)	(0.011)	(0.011)	(0.005)	(0.005)
width	0.006***	0.003***	0.058***	0.057***	0.013***	0.012***
	(0.0003)	(0.0005)	(0.002)	(0.004)	(0.001)	(0.002)
weight	0.001***	0.0003***	0.0001	0.001***	−0.001***	−0.0002**
	(0.00002)	(0.00002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
height	−0.002***	0.0005	−0.001	0.026***	−0.003***	0.002
	(0.0003)	(0.001)	(0.002)	(0.005)	(0.001)	(0.002)
domestic	0.005	−0.006**	1.835***	1.852***	0.404***	0.388***
	(0.003)	(0.003)	(0.028)	(0.023)	(0.013)	(0.013)
country1	−0.373***	−0.384***	0.703***	0.505***	0.092***	0.106***
	(0.004)	(0.003)	(0.039)	(0.034)	(0.017)	(0.016)
country2	−0.330***	−0.341***	−0.131***	−0.455***	−0.219***	−0.224***
	(0.004)	(0.003)	(0.039)	(0.033)	(0.016)	(0.015)
country3	−0.423***	−0.433***	0.024	−0.334***	−0.103***	−0.102***
	(0.004)	(0.003)	(0.041)	(0.036)	(0.017)	(0.017)
country4	−0.255***	−0.261***	−0.011	−0.276***	−0.310***	−0.323***
	(0.004)	(0.003)	(0.038)	(0.031)	(0.016)	(0.014)
Constant	43.650***	27.264***	−18.883***	80.667***	−23.514***	−2.609
	(0.503)	(0.674)	(4.649)	(5.695)	(1.965)	(2.684)
Observations	11,483	11,483	11,483	11,483	11,483	11,483
R^2	0.899	0.946	0.433	0.700	0.899	0.935
Adjusted R^2	0.899	0.944	0.432	0.690	0.899	0.933
Residual Std. Error	0.137 (df = 11471)	0.102 (df = 11121)	1.131 (df = 11470)	0.835 (df = 11120)	0.478 (df = 11469)	0.389 (df = 11119)
Note:						*p<0.1; **p<0.05; ***p<0.01

updated in physical dimensions), and we are able to discern positive coefficients for all of them. This makes sense, given the raw material requirements of size, while added horsepower requires a stronger, more expensive engine. These are all likely to drive costs. The negative coefficients on all four country dummies is due to the UK (the priciest country) being the default country.

The coefficient for domestic cars reveals that domestic production is associated with the car being 0.6% cheaper. This might partially explain why consumers prefer to buy domestic cars, and might itself be explained by trade barriers or lower transport costs.

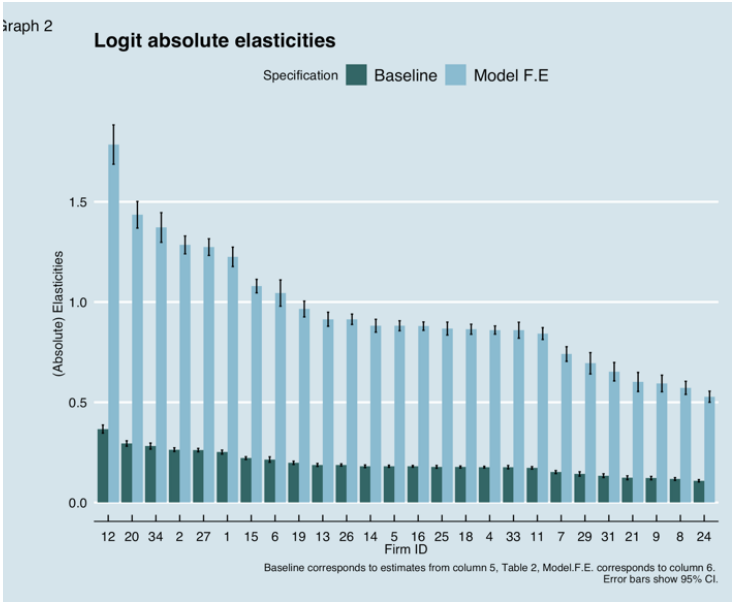
3. Market share characterisics

Table 3: Market share descriptives

Variable	Mean	S.e.	Min.	Max.
Market share	0.16%	0.00%	0%	3.03%
Market share segment	6.53%	0.00%	0.03%	100%
log(Market share)	-7.38	0.01	-10.95	-3.50
log(Market share segment)	-3.64	0.01	-8.29	0.00

Table 3 presents summary statistics of market-wide and within-segment market shares of car models. Each model's overall market share is low, averaging at 0.16% (the highest market share is the Fiat Uno's 3.03% in Italy 1986). However, the share of the outside good is substantial, around 80-90%, so it is of no surprise that market shares are small

Within-segment market shares are much higher, averaging at 6.5% rather than 0.16%, and some markets experience extreme concentration within segments, as hinted by the maximum segment share observed being 100%. (This large difference is attributable to the methodology using segment consumption as the denominator, which unlike the total market share calculation – which divides by number of households – neither assumes a yearly replacement cycle nor makes room for the outside good.) Extreme within-segment market shares skew luxurious, with the luxury segment most often dominated by a few models: of 91 observations above 50%, 63 were in the luxury segment; likewise 214 of the 626 observations above 25%.



Overall, we expect segmentation to be an important obstacle to substitutability between cars of different segments, leaving room for market power, especially in the luxury segment.

Table 4: Aggregated elasticity estimates

Elasticity	Mean	S.e.	Min.	Max.
Own price elasticity	-0.20	0.00	-1.59	-0.06
Own price elasticity (FE)	-0.95	0.00	-7.77	-0.27
Nested own price elasticity	-5.57	0.03	-47.50	-1.53
Nested own price elasticity (FE)	-6.43	0.03	-54.89	-1.77

Note: (FE) refers to model fixed effects estimates.

4. Logit estimation of demand and own-price elasticities

In the first two rows of Table 4, we present summary estimates of own-price elasticity of market share based on demand estimations from the logit specifications (as presented in Table 2, columns 3 and 4). Rows 3 and 4 present the same for our nested logit estimations. The mean is to be interpreted as the mean percentage change in the market share of the average firm when it changes its price by one percent. Max and min are analogously interpreted and the standard errors correspond to the estimates of the means.

Adding model fixed effects change the elasticities considerably: average own-price elasticity decreases from the -0.20 to -0.95, also visible on a firm basis in Graph 2. Importantly, there is large variation between the firm-level estimates (up to a factor exceeding three) with direct implications for the firms' optimal pricing strategies, suggesting that some firms. have customers more sensitive to price changes than other firms.

5. Nested logit estimation of demand and own-price elasticities

In Table 4, we present aggregated elasticity estimates based on demand estimations from specifications run with nested logit specifications (OLS and model fixed effects), which controls for within-segment market share as a way of modelling incomplete substitutability (and lower cross-price elasticities than otherwise) between cars of different segments. These resulting own-price elasticities dramatically differ from the non-nested results, inflating our average estimate from –0.95 to –6.43. This reflects that in this specification, market shares are more sensitive to price changes.

The substitution pattern parameter is high at 0.868 (coefficient for *ln_mshare_s*), meaning that the nest is highly important for explaining substitution patterns. That is, people tend to not view cars in different segments as substitutes. This makes the nested version likely to be more realistic than the logit specification, which models consumers' preferences as treating any pair of goods as equally substitutable with any third good. The nested logit also treats the "independence and irrelevant alternatives" assumption more flexibly. For these reasons, we use this specification when we analyse the effects of the VW, GM merger, allowing the merger to have varying effects across segments.

6. Suggesting instruments for solving endogeneity problems

Following the guidance of Goldberg & Verboven (2001), we suggest seeking instruments that shift market supply (relevance) without affecting demand (validity). Input prices are a natural candidate. Unfortunately, the car industry is nationally significant enough to tighten the trade-off between instrument relevance and validity – that is, between the input significantly moving car price on the one hand, and leaving demand unaffected on the other. Steel prices would reliably affect car prices, but could also move national economic activity and thus demand. Car paint prices risks low relevance, but this is testable.

A second alternative is labor strikes specific to the car industry, which would surely shift input costs through higher wages. Instrument validity requires: (a) that these specific workers' wages changes not feed through to a change in national demand for cars, which depends on the industry share of national employment, but is mitigated by the use of strike funds to compensate for forgone wages;

and (b) that national economic conditions not be a determinant of the decision to strike, which is unlikely.

7. Supply side analysis: Firm level prices, marginal costs and markups

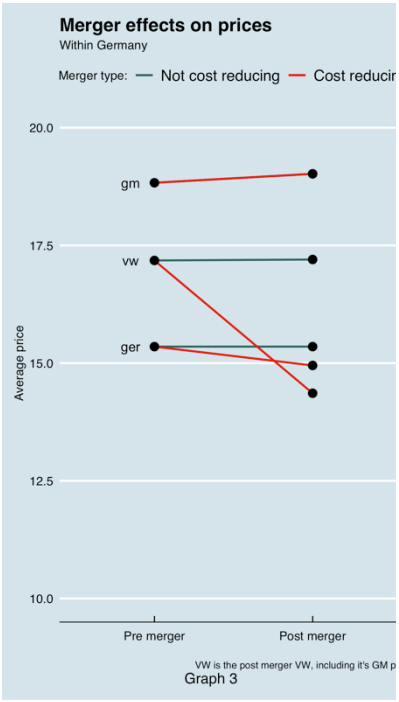
Table 5 present firm level averages, ranked by average car model price as calculated using the results from our preferred fixed effect nested logit model. These results are obviously economically meaningful (insofar as the assumptions of the model hold). The average price is, as discussed, the observed average price is what consumers paid for a car of a particular brand between 1970 and 1999 (in €000s in 1999 purchasing power), the marginal cost is the estimated average marginal cost manufacturers face when producing the car model (in the same units) and the mark up is simply the difference between these. The average Lerner index is the markups over price and a higher value indicate that a firm enjoys a higher market power, i.e. is either more efficient in production (lower marginal costs) or sells a product that consumers are willing to pay a premium for. Based on the Lerner index, the market is deemed as somewhat competitive, yet exhibits a tendency to price above marginal costs.

Table 5: Price changes by firm

Firm	Pre price	Post price	Post price (e)	Δ price%	Δ price % (e)	avg mc	avg markup	avg lerne
12	34.63	34.63	34.63	0.01	0.01	30.14	4.49	0.1
20	27.79	27.79	27.79	0.00	0.00	25.03	2.75	0.1
34	26.56	26.56	26.56	0.00	0.00	23.84	2.72	0.1
2	24.90	24.89	24.89	-0.16	-0.16	21.75	3.14	0.1
27	24.68	24.68	24.68	-0.01	-0.01	21.83	2.85	0.1
1	23.73	23.73	23.73	0.00	0.00	20.87	2.87	0.1
15	20.93	20.93	20.93	-0.43	-0.43	17.99	2.95	0.1
6	20.23	20.23	20.23	-0.00	-0.00	17.48	2.76	0.1
19	18.70	18.70	18.70	0.00	0.00	15.89	2.82	0.1
26	17.72	17.72	17.66	0.02	-3.41	14.85	2.87	0.2
13	17.70	17.70	17.70	0.01	0.01	14.98	2.73	0.1
5	17.12	17.12	17.12	0.02	0.02	14.09	3.02	0.2
14	17.08	17.08	17.08	0.01	0.01	14.32	2.76	0.1
16	17.05	17.05	17.05	0.00	0.00	14.20	2.86	0.2
25	16.80	16.80	16.80	0.01	0.01	14.05	2.75	0.1
18	16.76	16.76	16.76	0.01	0.01	13.86	2.91	0.2
4	16.67	16.67	16.67	-0.00	-0.00	13.81	2.86	0.2
33	16.66	16.66	16.66	0.00	0.00	13.82	2.84	0.1
11	16.32	16.32	16.32	0.01	0.01	13.58	2.74	0.1
7	14.34	14.34	14.34	0.01	0.01	11.63	2.71	0.2
29	13.45	13.45	13.45	0.01	0.01	10.72	2.72	0.2
31	12.64	12.64	12.64	0.00	0.00	9.88	2.76	0.2
21	11.65	11.65	11.65	0.00	0.00	8.91	2.74	0.2
9	11.50	11.50	11.50	0.01	0.01	8.79	2.70	0.2
8	11.08	11.08	11.08	0.00	0.00	8.35	2.73	0.2
24	10.22	10.22	10.22	0.00	0.00	7.50	2.72	0.2

Note: (e) denotes the efficient merger post price.

Apparently, the Lerner index is higher for lower priced cars (the correlation between price and the lerner index is -82%). We suspect this relationship is due to observing the price facing the consumer and not the dealer – whose presumably constant fee per sale would absorb a greater share of a cheap car's smaller absolute markup compared to a luxury car's larger absolute (correlation between markups and price is 17%). (correlation between markups and price is 17%).



Graph 3

8. Price effects of merger without cost efficiencies

Using the (nested logit with fixed effects) demand estimates above, we model the price effects of a hypothetical VW acquisition of GM's German operations. For each legacy company, we look at the average price across its models and compare to the counterfactual post-merger price. (Prices are not weighted by production quantities, and exclude the discontinued Opel Omega, belonging to the standard segment, so as to ensure like-for-like comparisons.) Graph 3, shows that a merger without efficiency gains raises the prices of legacy-GM models

from a mean of €18,830 to €19,020 (up 1.01%). This is a result of production reductions alone, as acquirer VW exploits its increased market power to tighten quantity, as per Cournot. VW's own legacy products also marginally increase in price by 0.1% from €17,180 to €17,200 as their respective market shares rise accordingly. All in all, the merger leaves is not large enough to dent the Germany-wide average car price, which stays still at €15,350. Sheer market size dilutes (but does not counteract!) the impact on VW and GM customers, leaving German consumers as a whole unaffected.

9. Price effects of merger with cost efficiencies

If we additionally assume efficiency gains from the merger (marginal cost reductions of 20% for the affected cars), the same exercise yields very different conclusions regarding price and consumer welfare. Graph 3 shows reductions in average car prices for the entire car market in Germany. Average legacy-GM model prices fall 15.7% to €15,860, while legacy-VW models fall 16.4% to €14,360. Thus the merged firm absorbs one quarter of the 20% efficiency savings itself, passing the rest onto the consumer. This feeds through to Germany wide average price reduction of 2.6% to €14,950. Comparing this to the prior scenario, efficiency savings are therefore the decisive determinant of whether a merger harms or benefits consumer welfare.

Looking at a segments individually, segments 1 to 4 witness average price reductions in the range of –2.0% -2.7%. The luxury segment, however, experiences an average fall of 4.7% from €30,300 to €28,870, but was completely unaffected in the scenario without efficiency gains. This suggests that the luxury sector contains a disproportionate number of different legacy-VW models. Hence, from a consumer point of view, a merger scenario with cost efficiencies is clearly favorable to one without cost efficiencies, as the former spills over to lower average prices in general.

10. Suggestion of additional features for extended analysis

The analysis conducted above focuses on the company level and production aspect of the merger. However, other important aspects of the businesses involved are likely to be affected as well. One aspect is sales and marketing. Consumer loyalties, powerful in the car market, are not captured by our observed product characteristics and could be affected by a merger: It is not certain (as the above conducted analysis assumes) that the demand for a particular brand is not affected by the merger. E.g., some customers might value the American values that GM symbolizes. Such customers might be less willing to buy their models after a merger, where the GM production has been taken over by German Volkswagen. To the contrary, it could also create interesting co-branding opportunities. Such aspects of sales and marketing should hence also be considered in merger analysis. This could for example be done by incorporating these aspects into the model above, by scoring of these aspects of the products and estimation of how they would change with the merger through consumer surveys.

Another aspect to be considered is the number of nests. We believe that a model using a richer variety of nests would more accurately capture the market behavior. It could also be that the nests should overlap. Also, the market share within the nest is endogenous, and should be explained via instruments.