The Evolution of Market Power in the US Automobile Industry*

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March 9, 2023

first order condition of each firm's profit maximization problem.

We find that median markups as defined by the Lerner index ($L = \frac{p-mc}{p}$) fell from 0.325 in 1980 to 0.185 by 2018 (Figure VI). However, as we detail below, although markups are useful

2.2 Price Instrument

To identify the price sensitivity of consumers, we rely on an instrumental variable that shifts price while being plausibly uncorrelated with unobserved demand shocks. We employ a cost-shifter related to local production costs where a vehicle is produced. For each automobile in each year, we use the price level of expenditure in the country where the car was manufactured, obtained from the Penn World Tables version 9.1 variable `pl_con`, lagged by one year to reflect planning horizons. Following Feenstra et al. (2015), we refer to this as the *Real Exchange Rate* (RXR). RXR is equal to the purchasing power parity (PPP) exchange rate relative to the U.S. divided by the nominal exchange rate relative to the U.S.. RXR varies with two sources that are useful for identifying price sensitivities. First, if wages in the country of manufacture rise, the cost of making the car will rise, which will in turn raise the real exchange rate via the PPP rising. Therefore, the real exchange captures one source of input cost variation through local labor costs. Another source of variation is through the nominal exchange rate. If the nominal exchange rate rises, so that the local currency depreciates relative to the dollar, a firm with market power will have an incentive to lower retail prices in the U.S., thereby providing another avenue of positive covariation between the real exchange rate and retail prices in the U.S.. Exchange rates were employed as instrumental variables for car prices in Goldberg and Verboven (2001), which is focused on the European car

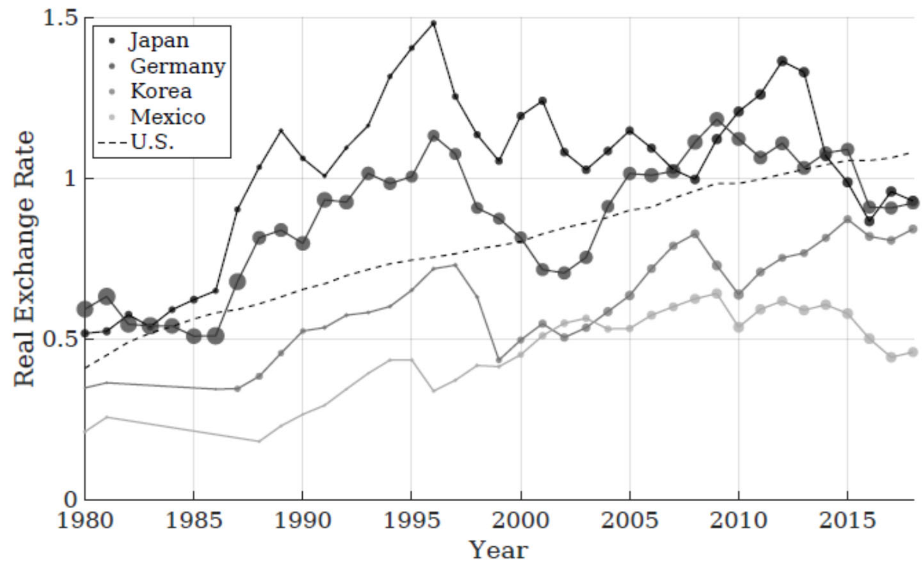


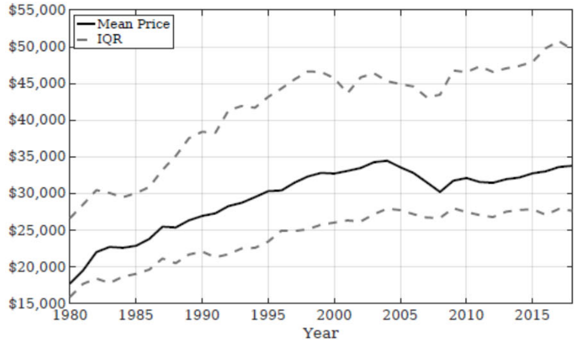
Figure I: Real Exchange Rates

Note: Lagged real exchange rates from Penn World Table 9.1. Size of dots corresponds to the relative number of sales by production country, except for U.S.A.

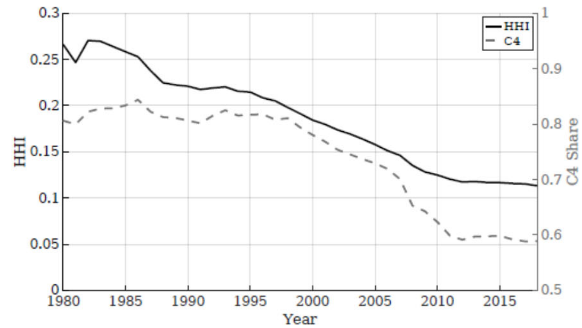
Table I: Summary Statistics

	Mean	Std. Dev.	Min	Max		Mean	Std. Dev.	Min	Max
Cars, N=6,130					**SUVs, N=2,243**				
Sales	52,088.60	72,750.83	10.00	473108.00	Sales	51,629.61	66,932.79	10.00	753064.00
Price	35.85	18.76	11.14	99.99	Price	40.41	14.94	12.75	96.94
MPG	22.67	6.82	10.00	50.00	MPG	18.01	4.98	10.00	50.00
Horsepower	178.21	83.41	48.00	645.00	Horsepower	232.33	74.92	63.00	510.00
Height	55.76	4.21	43.50	107.50	Height	69.01	4.38	53.00	90.00
Footprint	12,870.08	1,710.41	6,514.54	21,821.86	Width	13,790.90	1,785.69	8,127.00	18,136.00
Curbweight	3,181.94	639.51	1,488.00	6,765.00	Curbweight	4,246.05	854.30	2,028.00	7,230.00
US Brand	0.40	0.49	0.00	1.00	US Brand	0.40	0.49	0.00	1.00
Import	0.59	0.49	0.00	1.00	Import	0.59	0.49	0.00	1.00
Electric	0.02	0.14	0.00	1.00	Electric	0.01	0.12	0.00	1.00
Trucks, N=680					**Vans, N=641**				
Sales	140207.22	184123.33	12.00	891482.00	Sales	59,103.39	86,940.25	10.00	891482.00
Price	27.81	9.82	12.02	69.43	Price	36.05	17.13	11.14	99.99
MPG	17.83	4.36	10.00	50.00	MPG	20.94	6.58	10.00	50.00
Horsepower	189.17	90.31	44.00	403.00	Horsepower	192.18	83.88	44.00	645.00
Height	68.39	6.33	51.80	81.00	Height	60.95	8.41	43.50	107.50
Footprint	15,086.14	2,478.91	8,437.30	20,000.00	Footprint	13,392.63	1,968.92	6,514.54	21,821.86
Curbweight	4,043.42	1,114.94	1,113.00	7,178.00	Curbweight	3,561.21	897.77	1,113.00	8,550.00
US Brand	0.65	0.48	0.00	1.00	US Brand	0.44	0.50	0.00	1.00
Import	0.35	0.48	0.00	1.00	Import	0.55	0.50	0.00	1.00
Electric	0.00	0.00	0.00	0.00	Electric	0.02	0.13	0.00	1.00

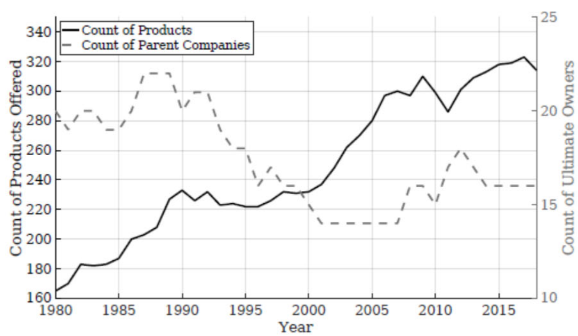
Notes: An observation is a make-model-year, aggregated by taking the median across trims in a given year. Statistics are not sales weighted. Prices are in 2015 000's USD. Physical dimensions are in inches and curbweight is in pounds.



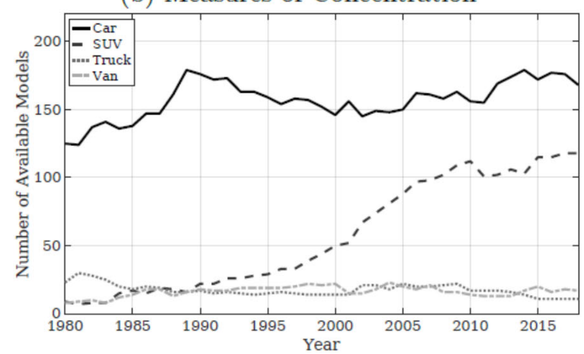
(a) Prices



(b) Measures of Concentration



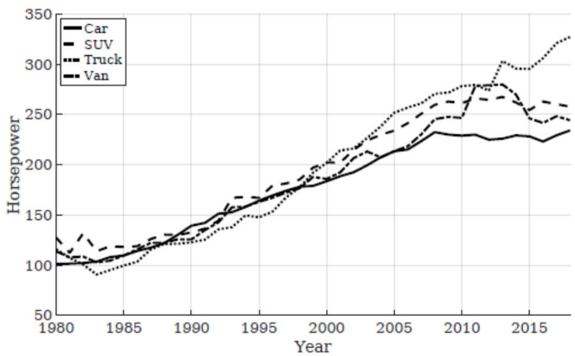
(c) Products and Manufacturers



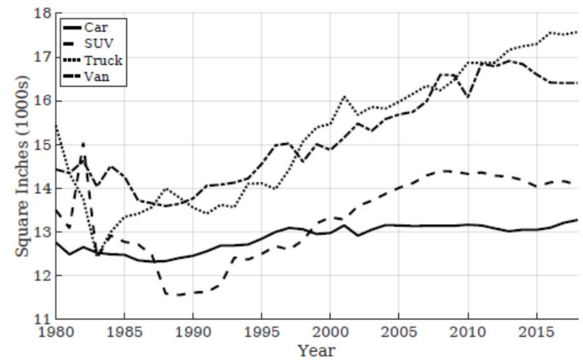
(d) Count of Products by Styles

Figure II: Prices and Market Structure, 1980-2018

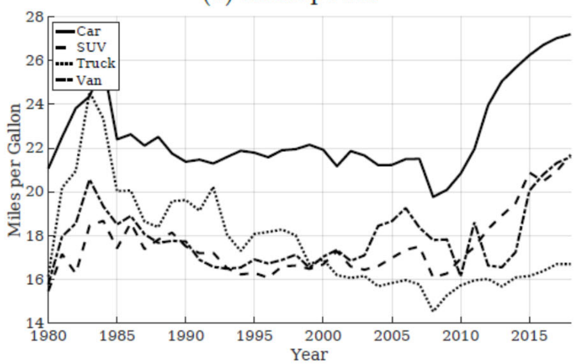
Notes: Panel (a) displays share-weighted average price along with the interquartile range. Panel (b): HHI (bold line and left scale) and C4 (dashed line and right scale) are defined at the parent company level, e.g. Honda is the parent company of the Honda and Acura brands. In Panel (c), the number of products corresponds to a model available in a given year in our sample. The style definitions referred to in Panel (d) are described in the text. Data is from Wards Automotive Yearbooks and the sample selection is described in the text.



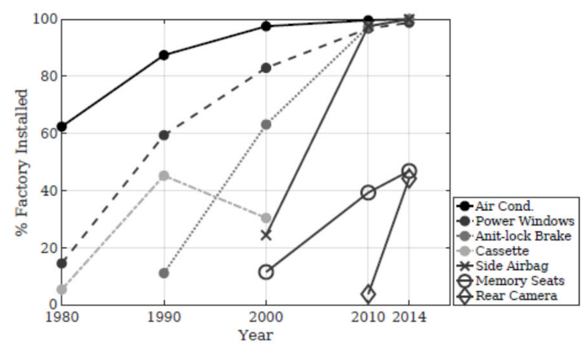
(a) Horsepower



(b) Footprint (length × width)



(c) Fuel Economy



(d) Additional Factory Installed Features

Figure III: Physical Vehicle Characteristics, 1980-2018

Utility is a linear index of a vector of vehicle attributes ($\mathbf{x}_{jt}$), price (p_{jt}), an unobserved vehicle specific term (ξ_{jt}), and an idiosyncratic consumer-vehicle specific term (ϵ_{ijt}).

$$u_{ijt} = \beta_{it}\mathbf{x}_{jt} + \alpha_{it}p_{jt} + \xi_{jt} + \epsilon_{ijt} \tag{1}$$

The index i denotes an individual in a given year. We specify and estimate parametric distributions of taste parameters β_i and α_i across individuals that depend on time-varying demographics and allow for unobservable heterogeneity. In our preferred specification, the parameters governing these distributions are fixed over time, but we also report estimates including time-varying components to parameters of the distribution of α_i and some dimensions of β_i. We assume that ϵ_{ijt} are independent draws from the standard Gumbel distribution.

Utility of the no-purchase option is $u_{i0t} = \gamma_t + \epsilon_{i0t}$, where γ_t reflects factors that change the utility of the no-purchase option from year to year, including business cycle fluctuations, urbanization, and durability of used automobiles. The average unobserved quality of new automobiles is also changing over time. We denote the mean utility of the choice set in year t relative to the base year as τ_t so that $\xi_{jt} = \tau_t + \tilde{\xi}_{jt}$ and assume that $E[\tilde{\xi}_{jt}|\mathbf{z}_{jt}] = 0$, where $\mathbf{z}_{jt}$ is a vector of instruments including $\mathbf{x}_{jt}$, year dummies, and an instrument for price (i.e., RXR).

It is well known that discrete choice models only identify utility relative to the outside good. Therefore, without further restrictions, we would be unable to separately identify yearly average unobserved quality, τ_t, and the value of the outside option, γ_t. To address this issue, we follow Pakes et al. (1993) and add the restriction that

$$\forall j \in \mathscr{C}_t : E[\xi_{jt} - \xi_{jt-1}] = E[(\tau_t - \tau_{t-1}) + (\tilde{\xi}_{jt} - \tilde{\xi}_{jt-1})] = 0 \tag{2}$$

where $\mathscr{C}_t$ is the set of *continuing* vehicles offered in both year t and $t-1$ that have not been redesigned by the manufacturer. Consider a model $j \in \mathscr{C}_t$ as a product nameplate and design

4.2 Firms

On the supply side, we assume automobile manufacturers, indexed by m, play a static, full information, simultaneous move pricing game each year. Manufacturers choose the price for all vehicles for all of their brands, $\mathcal{J}_t^m$, with the objective of maximizing firm profit. Observed prices form a Nash equilibrium to the pricing game. We assume a constant marginal cost, c_{jt}, associated with producing a vehicle in a given year. The pricing first order condition for vehicle j is:

$$s_{jt} + \sum_{k \in \mathcal{J}_t^m} (p_{jt} - c_{jt}) \frac{\partial s_{jt}}{\partial p_{kt}} = 0 \tag{6}$$

These first order conditions will be used in conjunction with the estimated demand system to solve for marginal costs for each product. Marginal costs will then be used to compute markups and for counterfactual analysis. For a subset of counterfactual analysis, we will parameterize marginal costs to depend on vehicle covariates including elements of $\mathbf{x}_{jt}$ and cost shifters excluded from demand which we describe in detail in Appendix B.2.

Table II: Logit Demand

	First Stage	Reduced Form	OLS	IV
Price			-0.334 (0.042)	-1.696 (0.598)
RXR	0.411 (0.110)	-0.697 (0.232)		
Height	-0.199 (0.048)	-0.064 (0.066)	-0.120 (0.069)	-0.401 (0.161)
Footprint	-0.117 (0.066)	0.348 (0.081)	0.318 (0.082)	0.149 (0.149)
Horsepower	0.768 (0.116)	-0.097 (0.070)	0.149 (0.067)	1.206 (0.472)
MPG	0.113 (0.036)	-0.062 (0.057)	-0.018 (0.062)	0.130 (0.116)
Curbweight	0.803 (0.111)	-0.493 (0.142)	-0.233 (0.140)	0.868 (0.541)
Num. of Trims	-0.115 (0.020)	1.097 (0.045)	1.060 (0.044)	0.902 (0.091)
Release Year	-0.081 (0.040)	-0.173 (0.054)	-0.195 (0.056)	-0.311 (0.091)
Yrs. Since Design	0.000 (0.012)	-0.145 (0.017)	-0.145 (0.017)	-0.144 (0.024)
Sport	0.480 (0.090)	-0.679 (0.105)	-0.523 (0.102)	0.134 (0.323)
Electric	0.765 (0.176)	-1.031 (0.255)	-0.791 (0.245)	0.267 (0.560)
Truck	-0.416 (0.154)	-0.485 (0.099)	-0.631 (0.107)	-1.190 (0.359)
SUV	-0.111 (0.117)	0.561 (0.100)	0.515 (0.105)	0.372 (0.214)
Van	-0.268 (0.161)	0.037 (0.126)	-0.060 (0.143)	-0.417 (0.330)
Mean Own Price Elas.	–	–	-1.20	-6.11
Implied Pass-through	0.117 (0.032)			
First Stage F-Stat	14.09			

Notes: Unit of observations: year-make-model, from 1980 to 2018. Number of observations: 9,694. All specifications include year and make fixed effects. Standard errors clustered by make in parentheses. All continuous car characteristics are in logs and price is in 2015 $10,000. Variables are logged and standardized.

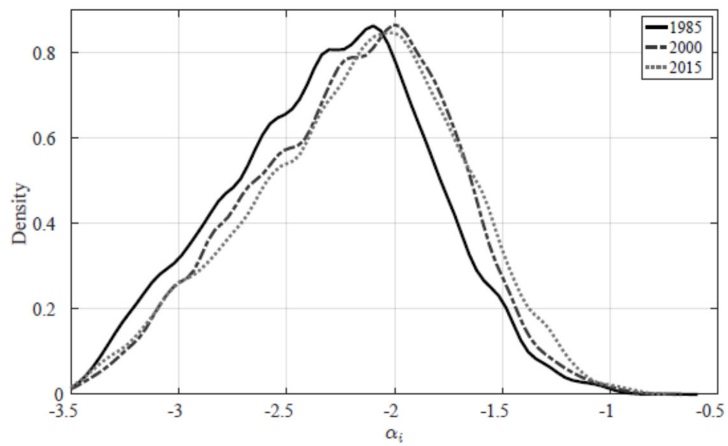


Figure IV: Distribution of Price Sensitivity

Note: Plot displays smoothed kernel regression of 10,000 draws from the estimated distribution of α_i, by year, for the baseline specification with constant $\bar{\alpha}$ over time.

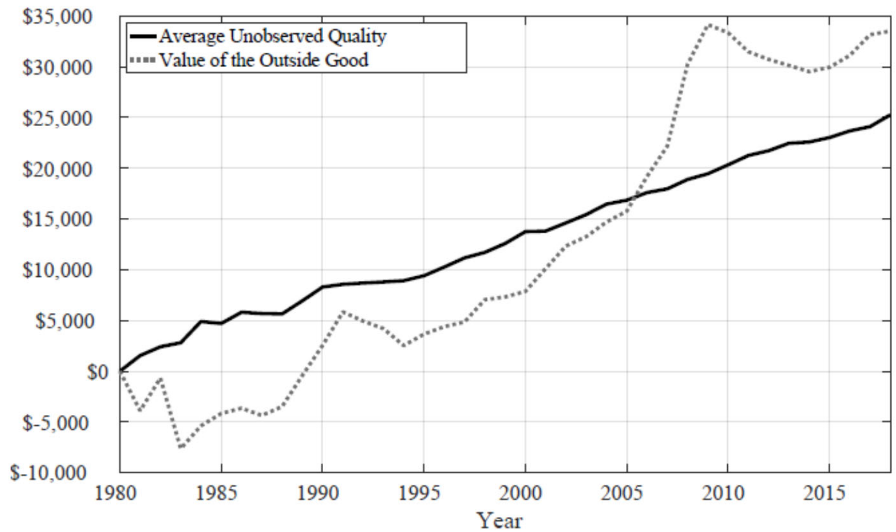
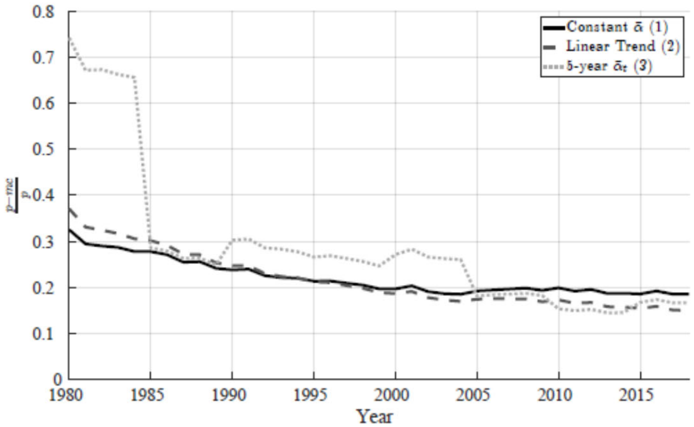
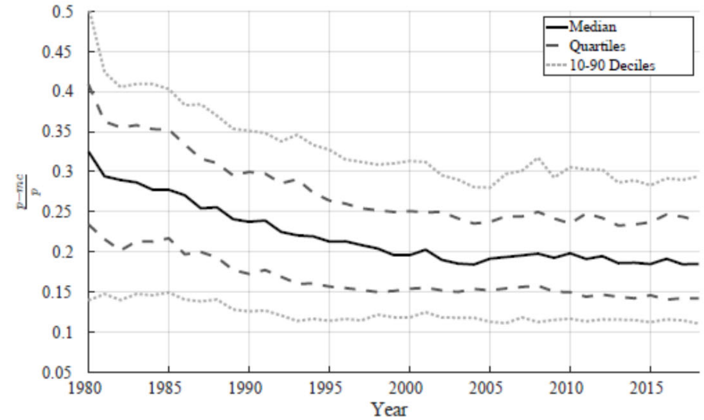


Figure V: Quality and Aggregate Components of Time Effects

Notes: Average unobserved quality, τ_t, and value of outside good, γ_t, in dollars. See text for estimation details.



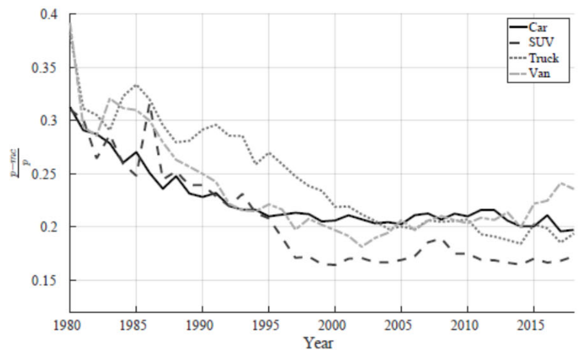
(a) Markups, Three Specifications



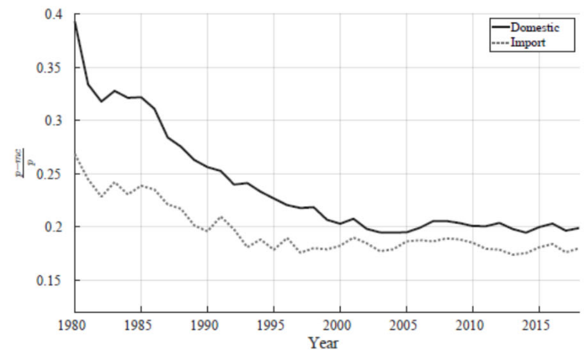
(b) Distribution of Markups

Figure VI: Markups

Notes: Panel (a) displays the median markup over time for three specifications of demand. Refer to Tables 4, 5, and 6 for demand estimates. Panel (b) displays the distribution of markups, over time, for demand specification (1).



(a) Markups by Vehicle Style



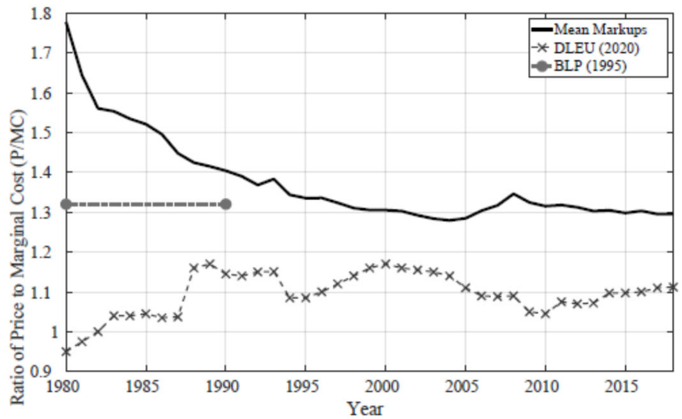
(b) Markups by Import Status

Figure VII: Markups over Time by Vehicle Style and Import Status

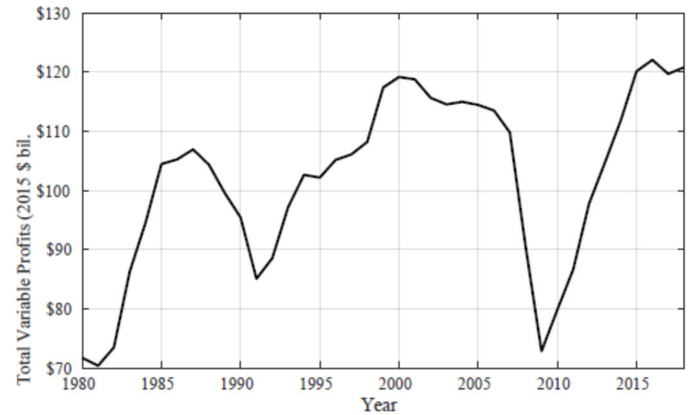
Note: Median markups across all vehicles. Vehicle style defined in the text. “Domestic” are those cars produced in the U.S., regardless of brand headquarters.

5.6 Comparison to production-based approach

De Loecker et al. (2020) use financial data from Compustat to estimate markups.[15] This approach uses a model of firm production and data on input expenditures and output revenue to estimate price over marginal cost ratios. In their baseline results, they estimate an increase in the sales weighted average price to marginal cost ratio (across all sectors) from 1.21 to 1.61 from 1980 to 2016. In addition to aggregate results, De Loecker et al. (2020) report estimates for specific industries, including the US auto industry. Figure XIa displays the time series of average price to marginal cost ratio from their work together with our own measure. We also include an estimate from Berry et al. (1995), which reports an average price to marginal cost ratio from 1971-1990. Both the level and trends in the price to marginal cost ratio differ from the estimates we derive, though both series are relatively flat from 1995 onward. In the right panel, we plot our estimates for total variable profits, which is the sum of price minus marginal cost multiplied by quantity sold over models in a year. Quantity thus enters directly into the right panel, but does not enter directly in our estimates in the left panel. Our estimates for total variable profits share some patterns with the De Loecker et al. (2020) estimates for markups, including an increase in the 1980's, a dip and recovery in the 1990's, and a dip and recovery around the Great Recession.



(a) Price over Marginal Cost



(b) Total Variable Profits

Figure XI: Comparison to De Loecker et al. (2020)

Notes: Panel (a) displays share-weighted mean price over marginal cost in our estimates, the estimate for share-weighted mean price over marginal cost in the U.S. automobile industry from De Loecker et al. (2020), and the average estimate across 1971-1990 from Berry et al. (1995). Panel (b) displays our estimate of total variable profits, quantity sold multiplied by margins, summed across all products.

6.1 Consumer surplus, producer surplus, and deadweight loss over time.

We first define a consumer surplus measure appropriate for our context. Typically, studies use the compensating variation of the product set relative to only the outside good being available to consumers. While this approach is straightforward, it is sensitive to changes in the valuation of the outside good over time. For example, suppose consumers choose to delay buying cars during a macroeconomic downturn. Then, in the down year the value of the outside good, γ_t, will be high as more consumers choose not to purchase. Similarly, suppose there is a significant improvement in public transit over time, this again is reflected in an increase in γ_t which will cause a decline in consumer surplus. Both of these cases will affect the standard consumer surplus measure, even when the quality of automobiles and their prices are held fixed. We construct a measure of consumer surplus that captures the attractiveness of the choice set and is straightforward to compare across years. For each year, instead of using the value of the outside option associated with that year, we average the compensating differential overall all of the 39 (1980-2018) estimated values of outside options.

To make things concrete, consider the compensating variation of a consumer being offered the inside product bundle in year t with the outside good valued at γ relative to receiving only the option to purchase this hypothetical outside good. Given our model assumptions, this is,

$$CS_t(\gamma) = \int_i \frac{1}{\alpha_{it}} \left[\log \left(\exp(\gamma) + \sum_{j \in \mathcal{J}_t} \exp(\beta_{it}\mathbf{x}_{jt} + \alpha_{it} p_{jt}^{(\gamma)} + \xi_{jt}) \right) - \gamma \right] dF_t(i). \tag{8}$$

In this calculation, $\mathbf{p}_t^{(\gamma)}$ represents the equilibrium vector of prices when firms face an outside good valued at γ.

The traditional consumer surplus measure is simply $CS_t(\gamma_t)$—the compensating variation that would make consumers in year t indifferent between the product bundle they face and only the outside good from that bundle. However we can also examine how the inside product bundle in year t would have been valued against the the outside good in other years, enabling a direct comparison of product sets across years. Our preferred surplus measure removes the influence of changes in the outside good over time by averaging over the outside good across all years in the sample,

$$\widetilde{CS}_t = \frac{1}{T}\sum_{v=0}^{T} CS_t(\gamma_v).$$

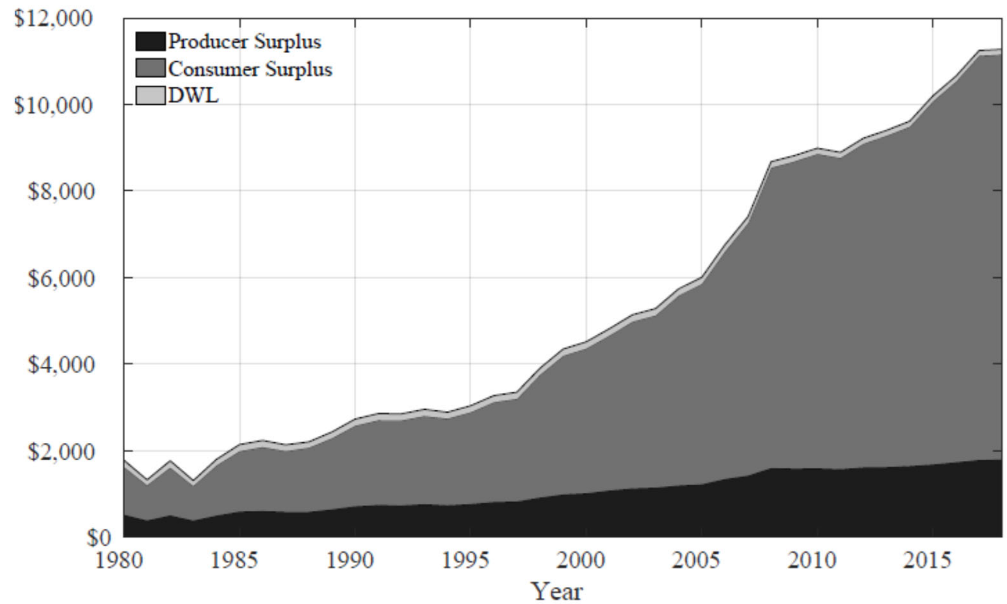
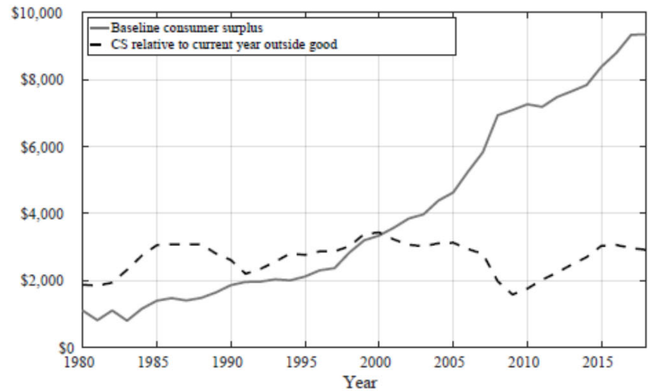
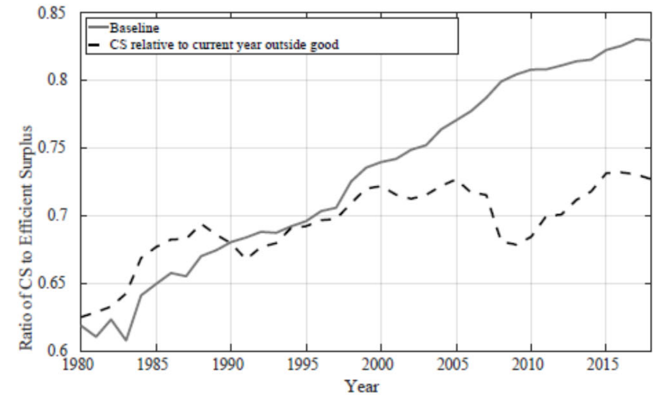


Figure XII: Consumer Surplus, Producer Surplus, and Deadweight Loss

Notes: Consumer surplus, producer surplus and deadweight loss. Consumer surplus in the compensating variation procedure detailed in the text. Deadweight loss is computed by netting consumer and producer surplus form efficient surplus, defined as the surplus available when prices equal marginal costs. Surplus measured in 2015 dollars.



(a) Consumer Surplus Comparison



(b) CS as a Share of Total Available Surplus

Figure XIII: Consumer Surplus Comparison

Notes: Panel (a) displays consumer surplus computed two ways: the baseline definition described in the text, and consumer surplus computed as the compensating variation to the current year outside good. Panel (b) displays the ratio of consumer surplus to total efficient surplus using both approached presented in panel (a), where efficient surplus is computed as consumer surplus when prices equal estimated marginal costs of production, vehicle by vehicle.