5321 Industrial Organization: Problem Set 2

Marek Chadim, Oscar Nilsson Hallgren, Elias Ljungqvist, Hugo Ryberg[1]

Program: STATA
Dataset: Björnerstedt and Verboven's "Cars-1".

1. Table 1 shows a summary of the data on all newly registered cars from five EU countries during a 30 year period, from 1970 to 1999. The countries are Belgium, France, Germany, Italy and the UK.

Table 1: Summary Statistics

	Mean	SD	Min	Max	N
1 if produced domestically	0.189	0.391	0.000	1.000	11483
Number of new car regs	19911.439	37803.598	51.000	433694.000	11483
Price (in 1000 EUR)	18.497	8.923	5.261	150.335	11483
Horsepower (kW)	57.264	23.890	13.000	169.500	11483
Fuel efficiency	6.729	1.710	3.800	18.600	11483
Width (cm)	164.457	9.568	122.000	188.000	11483
Height (cm)	140.443	4.631	117.500	173.500	11483
Weight (kg)	980.231	225.150	520.000	1910.000	11483

Source: Björnerstedt and Verboven's Cars-1 dataset

The mean of the domestic variable hints to the differences in market sizes and import penetration. The amount of sold cars will trivially be larger in more populous countries, but the degree to which they import cars produced in another country will vary a lot. We can see that since the mean of the domestic dummy is 0.189, many car sales done in these countries consists of cars manufactured outside the country in which it is being sold.

The average price for a car in 1999 purchasing power is 18497 EUR. The price ranges from the cheapest car, sold for 5261 EUR, to the most expensive sold for 150335 EUR. It is reasonable to expect the distribution to be skewed somewhat to the right by the very pricey luxury cars. The standard deviation is relatively large, hinting to a relatively wide variety of cars, which we also see in the data ranges from standard to luxury. We can also see that the characteristics, from horsepower down to weight, exhibits quite a large range. The wide range of price and characteristics show that the market caters to a broad range of consumers, from budget to premium buyers.

2. In the hedonic price equation/model the dependent variable is the logarithm of the price of cars and the independent variables are the characteristics of the cars. By taking the natural log of the price, we are modeling percentage changes in price with respect to changes in these characteristics.All estimates presented in Table 2 below are significant at the 99% level, allowing us to reject the Null of the effect being 0. A unit increase in horsepower of a car, one additional kW, increases the price by 0.83%, indicating that consumers are willing to pay a premium from powerful cars. A unit increase in fuel efficiency, one additional litre per km at 90km/h, increases the price by 5.9%, indicating that consumers are willing to pay quite some more if they do not have to refuel the car as often. A one centimeter increase in the width leads to a 0.47% increase in price, perhaps hinting to the fact that somewhat more leg-space is worth some more. However, one additional centimeter in height reduces the price by 0.29%, perhaps related to sports cars being low for aerodynamic reasons while also being acceptable to pay more for, hinting to the fact that more space horizontally is not worth

[1] 42624@student.hhs.se, 42599@student.hhs.se, 42613@student.hhs.se, 42597@student.hhs.se

paying additionally for while vertically it is. Finally, if the car weighs one additional kilo, the price increases by a mere 0.04%, which does not hint to much other than that it could do with that people prefer wider cars with more horsepower (i.e. larger engine), which also increases weight.

Table 2: Hedonic Price Regression

	logprice
Horsepower (kW)	0.0083***
	(0.0002)
Fuel efficiency	0.0591***
	(0.0015)
Width (cm)	0.0047***
	(0.0005)
Height (cm)	-0.0029***
	(0.0005)
Weight (kg)	0.0004***
	(0.0000)
Observations	11483

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3. A household has the utility function:

$$u_{ijm} = \beta x_{jm} + \alpha p_{jm} + \xi_{jm} + \epsilon_{ijm}$$

Where ϵ_{ijm} is household taste shocks distributed according to an extreme value type 1 distribution. Calculating aggregate utility we get the market share s_j:

$$s_j = \frac{e^{\beta x_{jm} + \alpha p_{jm} + \xi_{jm}}}{1 + \sum_{k=1}^{J} e^{\beta x_{jm} + \alpha p_{jm} + \xi_{jm}}}$$

And the outside good share s_0:

$$s_0 = \frac{1}{1 + \sum_{k=1}^{J} e^{\beta x_{jm} + \alpha p_{jm} + \xi_{jm}}}$$

Dividing by each other and taking logs we get the following Logit specification:

$$ln\left(\frac{s_{jm}}{s_{0t}}\right) = \beta x_{jm} + \alpha p_{jm} + \xi_{jm}$$

Where the LHS is the difference between the natural logarithm of the markets share of all j products/cars and the market share of the outside good. x is the observable car characteristics, p is price and ξ is the error/residual where all the unobserved characteristics "lives". We can further decompose it: $\xi_{jm} = \xi_j + \xi_m + \eta_{jm}$, where ξ_j are common unobserved product characteristics for product j, ξ_m are common shocks to all products in country m and η_{jm} are individual shocks for product j in country m (or time t). This allows us to capture some components of the unobserved characteristics. In this case, we control for country and car model fixed effects.

Table 3: Logit

	ln_dmshare
Price (in 1000 EUR)	-0.051***
	(0.003)
Horsepower (kW)	-0.011***
	(0.001)
Fuel efficiency	-0.056***
	(0.010)
Width (cm)	0.062***
	(0.004)
Height (cm)	0.030***
	(0.005)
1 if produced domestically	1.852***
	(0.023)
Year	-0.045***
	(0.003)
Constant	69.779***
	(5.093)
Country Fixed effects	YES
Car Model Fixed effects	YES
Observations	11483

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Where *ln_dmshare* is $ln(s_j) - ln(s_0)$, our LHS. Our α is -0.051. As discussed in class, we here have an endogeneity problem. Price is probably correlated with ξ which leads to a biased α estimate. A negative alpha suggests that an increase in price leads to a relatively smaller (log) market share for product j, which is consistent with economic theory in the sense that a price increase, ceteris paribus, has some consumers switch from product j to some other product k which is now relatively cheaper. The firm producing j will see a lower demand for their product and thus loose market share.

An important weakness with this model is what is called the Independence of Irrelevant Alternatives (IIA). In multinomial logit models (when the dependent variable has more than 2 categories like in this case), the odds of choosing one category over another are assumed to be unaffected by the presence (or absence) of additional alternatives. This can be quite unrealistic in some choice scenarios, especially when we know from question 1 that we have quite the span of different types of cars. Therefore, a good mitigation step is to enhance the model to a **nested** logit model.

4. The nested logit equation is an extension of the logit model that allows for some relaxation of the IIA property by grouping choices into "nests" or segments. Choices can be naturally partitioned into groups where choices within the same group are more similar to each other than to choices in different groups. For example, choices within luxury car segment and those for larger family cars are likely to differ. The nested logit equation can be written as follows:

$$ln\left(\frac{s_{jm}}{s_{0m}}\right) = \beta x_{jm} + \alpha p_{jm} + \sigma ln(s_{j|g}) + \xi_{jm}$$

Where $s_{j|g}$ is the market share of product j in nest g. $\sigma \in [0,1]$ measures the correlation of tastes within each nest. A sigma $= 0$ means we are back with a plain logit model. A larger sigma however indicates that the within-nest choice probabilities are largely equal, and in general means that there is some within-nest correlations that we can capture.

Table 4: Nested Logit

	ln_dmshare
Price (in 1000 EUR)	-0.049***
	(0.001)
ln_mshare_s	0.868***
	(0.004)
Horsepower (kW)	0.003***
	(0.001)
Fuel efficiency	-0.026***
	(0.005)
Width (cm)	0.011***
	(0.002)
Height (cm)	0.001
	(0.002)
1 if produced domestically	0.388***
	(0.013)
Year	-0.003*
	(0.001)
Constant	0.306
	(2.396)
Country Fixed effects	YES
Car Model Fixed effects	YES
Observations	11483

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Where *ln_dmshare* is still $ln(s_j) - ln(s_0)$ and *ln_mshare_s* is the natural logarithm of the market share of each car model in its segment. The car market is classified into five different segments: subcompact, compact, intermediate, standard, and luxury. Our α is -0.049 and our σ is 0.868. By nesting we get a larger alpha, meaning less negative effect on the market share (compared to before) following a price increase. One should expect this result because we now capture some of the effects of different segments. If a firm increases the price of their luxury brand, it might hurt the market share within that segment but not as much compared to other segments such as standard, since the choice probabilities between these segments are somewhat more "differentiated" or does not have a strong cross-elasticity. The estimate of sigma is quite large and positive which suggest that if we have a large market share within the segment, we would have a larger total market share as well, which coincides with economic theory. Importantly, it is also different from 0, which is a necessary requirement for the nested logit to actually have some improvement over the plain logit. We can therefore confirm that the problem of IIA is, to some extent, eliminated within the nests, although not across nests. The fact that we obtained a negative alpha is furthermore, as discussed in exercise 3, also consistent with economic theory since larger prices should lead to less demand and hence a smaller market share.

5. When estimating demand, we need variables that provide exogenous sources of variation, in this case in prices, as well as in quantities. This is because the price is determined endogenously by the fact that it possibly is correlated with ξ_{jt} (the interpretation of ξ_{jt} as unobserved product quality suggest that it will be positively correlated with the product's price). Furthermore by virtue of the firms first order conditions, it will also be correlated with the prices and market shares of the other products. Identification of the demand side parameters requires thus an instrumental variables matrix Z, with rank at least as large as the number of parameters to be estimated (including product's own characteristics assumed to be exogenous). Examples of variables that can provide this exogenous variation, by shifting the producers' supply, while being excluded from the demand equations, are cost shifters + Hausman, Waldfogel and BLP instruments.

   Cost shifters such as marginal cost, tax, material costs or exchange rates between a destination market and the source countries could work as instrument as long as they are mean independent of demand shocks ξ_{jt} (consumers should only care about them through their effect on prices). Hausman instrument is a cost side instrument that uses as proxy the contemporaneous price of the same good averaged across other locations (need costs to be correlated across locations, but not unobserved quality). The logic of this instrument is that even if we do not observe producer-specific cost shifters, variation in costs is likely present and partially responsible for variation in the prices a firm sets in all its markets. Thus, an observed price increase of a certain firms car model (say Honda's honda civic) in one market can signal a change in the firms's costs that also shifts its equilibrium price in another market. In our dataset we have the variable *loc* for each geographical market. Generating a new variable for perhaps prices of honda civic in Japan as an instrument for explaining the exogenous variation in price of honda civic in the other locations/markets. The key assumption is that the price in market t is mean independent of ξ_{jt} conditional on the exogenous δ_{jt}. This would fail if the demand shocks $\xi_{jt'}$ and ξ_{jt} (in two different markets) are correlated. This can happen by seasonal variation in demand not captured by the model through the observed product characteristics.

   Waldfogel intruments are average consumer characteristics in nearby locations: if retailers "price uniformely" (DellaVigna and Gentzkow (2019)) neighbors' demographics will affect your prices.

   BLP instruments use the exogenous variation in competing products: eg. average characteristics x_{kt} of competing products $k \neq j$ Equally, the validity of the BLP instruments depends on their mean independence from the demand shocks ξ_{jt}. As we know the demand for some car, say Fiat Panda, also depends on the characteristics of all related goods (more so on those who are closely related within the same segment/nest). This fact can be used. The key, again, is that we can maintain the assumption of mean independence between δ_{jt} and ξ_{jt}. Then the entire set δ_{-jt} of competitors' product characteristics can serve as instruments. These instruments affect all quantities through the demand system and also prices; the equilibrium markup for good j depends on the elasticity of the residual demand for good j , which again depends on the characteristics of all goods.

6. Assuming that firms compete on prices, we can derive an expression for implied marginal cost. The first order condition for a profit-maximizing firm can be rearranged to,

$$\text{mc} = p + \frac{s_j}{\frac{\partial s_j}{\partial p}}.$$

Equilibrium marginal costs will depend on the elasticity of demand and hence the assumed substitution pattern of consumers. Therefore, our choice of logit or nested logit will affect our estimates. The price derivative in the logit case is

$$\frac{\partial s_j}{\partial p_j} = -\alpha s_j(1 - s_j) \implies \text{mc} = p - \frac{1}{\alpha(1 - s_j)},$$

whereas with nested logit it is equal to

$$\frac{\partial s_j}{\partial p_j} = -\alpha s_j \left(\frac{1}{1-\sigma} - \frac{\sigma}{1-\sigma} s_{jg} - s_j \right) \implies \text{mc} = p - \frac{\frac{1-\sigma}{\alpha}}{1 - \sigma s_{jg} - (1-\sigma)s_j}.$$

In Table 5 we present estimates of marginal costs and a Lerner index under the different assumptions. The logit assumption produces lots of negative marginal costs and Learner indexes above 2, which is implausible. However, the numbers with nested logit make more economic sense. Firms have marginal costs around 10-20 and charge mark-ups around 20%. We conclude that the nested logit choice is more appropriate when modelling the demand for cars.

Table 5: Firm Level Averages

Firm	MC		Lerner		Average Price
	Logit	Nested	Logit	Nested	
BMW	0.398	17.21	1.131	0.167	20.194
Fiat	-4.527	12.444	1.571	0.223	15.277
Ford	-5.282	11.651	1.552	0.226	14.557
Honda	0.305	17.322	1.182	0.166	20.094
Hyundai	-6.865	10.204	1.714	0.235	12.915
Kia	-8.961	8.116	2.007	0.274	10.814
Mazda	-5.131	11.934	1.48	0.203	14.651
Mercedes	5.786	22.203	0.913	0.149	25.598
Mitsubishi	-3.828	13.233	1.347	0.185	15.955
Nissan	-4.357	12.673	1.461	0.204	15.438
GM	1.229	18.141	1.02	0.163	21.054
PSA	-3.574	13.388	1.418	0.205	16.244
Renault	-4.326	12.551	1.478	0.221	15.518
Suzuki	-10.489	6.582	2.242	0.307	9.289
Toyota	-5.228	11.819	1.56	0.221	14.56
VW	-0.822	16.14	1.368	0.196	18.99
Volvo	3.374	20.332	0.876	0.125	23.167
Daewoo	-5.909	11.148	1.617	0.222	13.871

7. Merger simulation between VW and GM, 1998 in Germany, in absence of efficiency gains:

Table 6: Unweighted Average Prices Before and After Merger

Firm	Pre-merger	Post-merger	Relative Change
BMW	17.946	18.011	0.003
Fiat	15.338	15.355	0.002
Ford	13.093	13.143	0.004
Honda	15.778	15.790	0.001
Hyundai	12.912	12.915	0.000
Kia	11.276	11.277	0.000
Mazda	14.229	14.242	0.001
Mercedes	20.114	20.128	0.001
Mitsubishi	15.832	15.849	0.001
Nissan	15.101	15.111	0.001
GM	19.921	20.854	**0.060**
PSA	16.397	16.411	0.001
Renault	15.292	15.313	0.002
Suzuki	9.225	9.229	0.000
Toyota	13.019	13.029	0.001
VW	17.182	17.749	**0.043**
Volvo	22.149	22.165	0.001
Daewoo	13.483	13.486	0.000

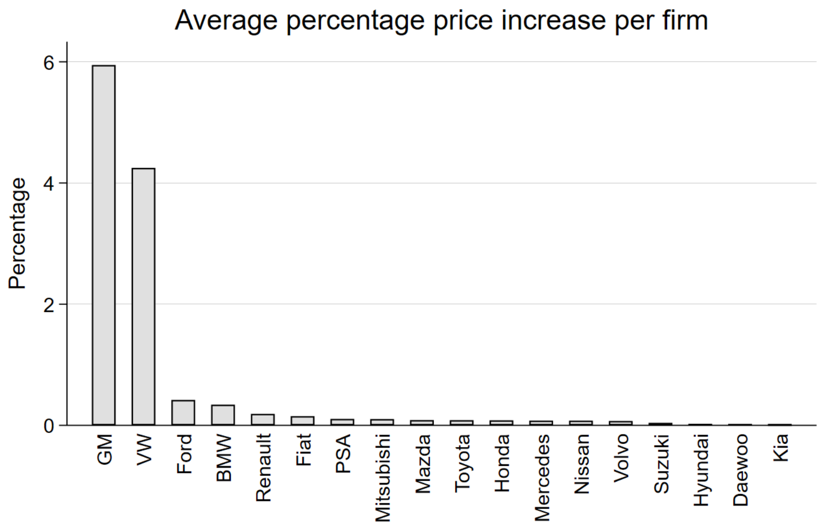

Table 7: Changes in Surpluses

	Change
Consumer Surplus	-1,201,018
Producer Surplus	811,937

In this merger we assume absence of efficiency gains. We can see a sharp increase in prices for the merging firms, while only some of the outside firms (or competitors) raise their prices. We have a negative consumer surplus and a positive producer surplus. A competition authority following the consumer welfare standard should not approve this merger, due to the loss in consumer surplus from the merger.

8. Merger simulation between VW and GM, 1998 in Germany, with efficiency gains (a 10% reduction in MC):

Table 8: Unweighted Average Prices Before and After Merger

Firm	Pre-merger	Post-merger	Relative Change
BMW	17.946	17.836	-0.005
Fiat	15.338	15.338	0.000
Ford	13.093	13.104	0.001
Honda	15.778	15.777	0.000
Hyundai	12.912	12.912	0.000
Kia	11.276	11.276	0.000
Mazda	14.229	14.230	0.000
Mercedes	20.114	19.899	-0.008
Mitsubishi	15.832	15.832	0.000
Nissan	15.101	15.102	0.000
GM	19.921	19.653	**0.004**
PSA	16.397	16.397	0.000
Renault	15.292	15.297	0.000
Suzuki	9.225	9.225	0.000
Toyota	13.019	13.020	0.000
VW	17.182	16.831	**-0.003**
Volvo	22.149	22.136	-0.001
Daewoo	13.483	13.483	0.000

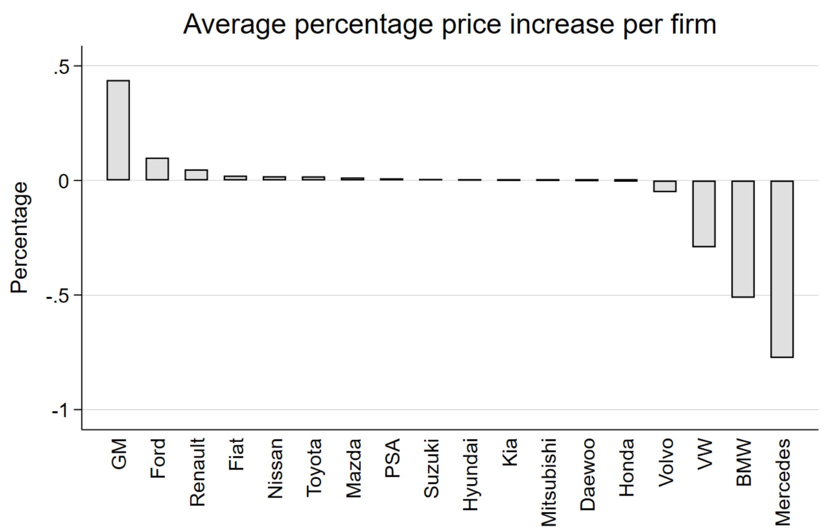

Table 9: Changes in Surpluses

	Change
Consumer Surplus	32,533
Producer Surplus	1,707,419

In this merger we assume there are some efficiency gains, namely a 10% decrease in marginal cost. Compared to the previous case, the firm now has two possible ways of increasing profits: 1) increase prices and decrease output or 2) decrease prices and increase output. If the efficiency gains are large enough, the second option will dominate, leading to an increase in consumer surplus (Motta). This seems to be the case here, which is a clear contrast to the previous question. We could think that the merger between the GM and VW lead them to be more efficient by for example better organise their transportation network, economies of scale or joint production, resulting in savings in unit costs. The profitable strategy, based on the changes in surpluses, seems to have been to reduce prices and attract more customers, yielding higher CS. A competition authority following the consumer welfare standard should approve this merger. However, it is worth noting that the relative change in price is negative for VW but positive for GM. Furthermore, there are other brands such as BMW, Mercedes and Volvo who seems to be decreasing prices. Hence, the increase in CS is not necessarily all due to the price decrease from the merging firms but a price decrease from other brands as well.

9. Merger simulation between VW and GM, 1998 in Germany, with a seemingly structural remedy: from the question we can imagine that VW only were allowed to merge with GM with the condition that they did not acquire the 3 Opel models. This leads to a 9% efficiency gain for the merged entity and a 2% loss in efficiency for the remaining Opels.

Table 10: Unweighted Average Prices Before and After Merger

Firm	Pre-merger	Post-merger	Relative Change
BMW	17.946	17.835	-0.005
Fiat	15.338	15.330	-0.001
Ford	13.093	13.079	-0.001
Honda	15.778	15.777	0.000
Hyundai	12.912	12.911	-0.000
Kia	11.276	11.276	-0.000
Mazda	14.229	14.224	-0.000
Mercedes	20.114	19.931	-0.007
Mitsubishi	15.832	15.823	-0.001
Nissan	15.101	15.100	-0.000
Opels	19.921	19.660	**0.000**
PSA	16.397	16.390	-0.000
Renault	15.292	15.287	-0.000
Suzuki	9.225	9.223	-0.000
Toyota	13.019	13.016	-0.000
VW/GM	17.182	16.495	**-0.032**
Volvo	22.149	22.131	-0.001
Daewoo	13.483	13.483	-0.000

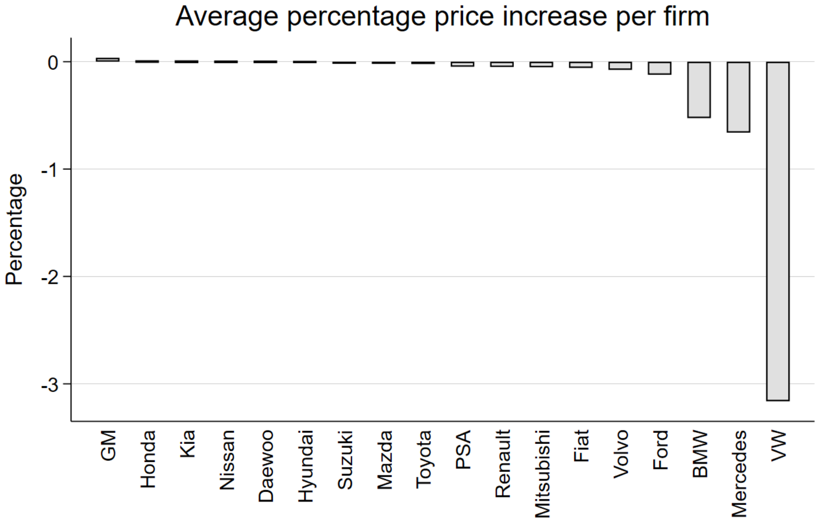

Table 11: Changes in Surpluses

	Change
Consumer Surplus	359,308
Producer Surplus	1,001,758

Compared to the previous question, we see a higher consumer surplus and a lower producer surplus. It seems like the remedy managed to transfer some surplus from the producers to the consumers. The price change from the merger is null for GM while VW display a greater reduction in prices. It could be because in the previous question, they have more market power and face less competition. In this case, they have less efficiency gains but still reduce price even further, which could be explained by that in this state of the market they have a smaller market share and face more competition which forces the merged entity to reduce price. Another point is that the PS decreases proportionally more than the CS increases. This is probably due to the efficiency losses that the Opels suffers.

10. The nested logit model facilitates linear estimation techniques but only accounts for simple correlation patterns between products. Therefore, the full random coefficients model (Berry et al. (1995)) might serve as a viable extension or robustness check for the analysis. This approach would also enable the incorporation of information on the empirical distribution of consumer characteristics (such as the actual distribution of income) into the random coefficients framework, allowing for the examination of the heterogeneous impacts of mergers, indicating which customers benefit more or less. A limitation of our approach is that it does not address "coordinated effects," investment incentives, upstream bargaining power, etc. Further extensions include addressing what level of cost efficiency would be sufficient to result in zero net effect on prices (Nevo (1998)), incorporating multiple endogenous product characteristics (Fan (2013)), and discriminating between models of supply (Berry and Haile (2014)): The degree of joint profit maximization between firms after the merger could then be incorporated (the profits of other firms are as important as own profits in our setting). Moreover, upward pricing pressure and SSNIP-tests calculated in a multi-product setting, relevant for competition policy, could also enrich the market analysis. Last but not least, we could present the estimated own and cross-price demand derivatives as Diversion Ratios: the fraction of unit sales lost by the first product due to an increase in its price that would be diverted to the second product. Diversion ratios between products sold by one merging firm and products sold by the other merging firm can be very informative for assessing unilateral price effects, with higher diversion ratios indicating a greater likelihood of such effects(Horizontal Merger Guidelines, 2010).

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