"Airbus versus Boeing Revisited: International Competition in the Aircraft Market,"

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A.1 Demand Elasticities Implied by Bertrand Equilibrium

The expression for own and cross-price elasticities of demand derived from market share equation (1) are as follows:

$$\eta_{j,j} = \frac{\partial s_j}{\partial p_j}\frac{p_j}{s_j} = -\alpha p_j s_j + \alpha p_j\left(\frac{1}{(1-\sigma)} - \frac{\sigma}{(1-\sigma)}s_{j|g}\right)$$

$$\eta_{j,k} = \frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j} = -\alpha p_k s_k \quad if\ \ j \neq k \quad k \notin g, j \in g$$

$$\eta_{j,k} = \frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j} = -\alpha p_k s_k\left(\frac{\sigma}{(1-\sigma)}\frac{s_{k|g}}{s_k} + 1\right) \quad if\ \ j \neq k \quad j,k \in g$$

where η_{jj} is product j's own-price elasticity of demand, η_{jk} is the cross-price elasticity between product j and k, and differs depending upon whether the products belong to the same market segment.

A.2 Cournot Equilibrium

When the firms compete in quantities, the first order condition for profit maximizing with respect to market share for product j at time t in firm f yields:

$$\sum_{k \in F_{ft}} \frac{dp_{kt}}{ds_{jt}} * s_{kt} + (p_{jt} - c_{jt}) - E_t\left[\sum_{n=1}^{\infty} \beta^n q_{jt+n}\frac{\partial c_{jt+n}}{\partial q_{jt}}\right] = 0$$

To derive a pricing equation for each product j at time t, we use vector notation. Let p_t denote a Jx1 price vector, c_t a Jx1 vector of marginal costs, and s a Jx1 vector of market shares of all products offered at time t (time subscript is omitted in the notation). Let Ω_t^c be a JxJ matrix

whose element in row k and column j equals $-\frac{\partial p_{jt}}{\partial s_{kt}}$ if aircraft j and k are produced by the same firm and 0 otherwise. Let f_t be a Jx1 vector whose element in row j (f_{jt}) equals $E_t\left[\sum_{n=1}^{\infty}\beta^n q_{jt+n}\frac{\partial c_{jt+n}}{\partial q_{jt}}\right]$. We can then rewrite the first order profit maximizing conditions in vector form as:

$$p_t - \Omega_t^c s_t = c_t + f_t \equiv c_t^*$$

We still need to find the expression for $\frac{\partial p_j}{\partial s_k}$ (time subscripts are omitted). As discussed in section 2.1, Berry (1994) shows that one can invert the predicted market share function for product j (1) to obtain an analytic expression for the mean utility level of product j δ_j as a function of product market share and distributional parameter σ:

$$\delta_j(S,\sigma) = \ln S_j - \sigma \ln S_{j|g} - \ln S_o .$$

Moreover, remember that the mean utility level of product j is defined as $\delta_j \equiv x_j\beta - \alpha p_j + \xi_j$.

Thus:

$$\frac{\partial p_j}{\partial s_j} = \frac{\partial p_j}{\partial \delta_j}\frac{\partial \delta_j}{\partial s_j} = \frac{1}{\alpha}\left(\frac{1}{s_j} - \frac{\sigma}{s_j} + \frac{\sigma}{s_g} + \frac{1}{s_o}\right)$$

where s_g is the market share of the market segment g in the overall market and s_o is the market share of the outside good.

Similarly,

$$\frac{\partial p_j}{\partial s_k} = \frac{\partial p_j}{\partial \delta_j}\frac{\partial \delta_j}{\partial \delta_k}\frac{\partial \delta_k}{\partial s_k} = \frac{1}{\alpha}\frac{\partial \delta_j}{\partial \delta_k}\left(\frac{1}{s_k} - \frac{\sigma}{s_k} + \frac{\sigma}{s_g} + \frac{1}{s_o}\right).$$

We still need to obtain $\frac{\partial \delta_j}{\partial \delta_k}$ in the above expression. By implicit function theorem:

$\frac{\partial \delta_j}{\partial \delta_k} = -\frac{\frac{\partial s_j}{\partial \delta_k}}{\frac{\partial s_j}{\partial \delta_j}}$. Differentiating (1) with respect to mean utility of product j and k thus yields:

$$\frac{\partial \delta_j}{\partial \delta_k} = \begin{cases} \dfrac{s_k\left(\frac{\sigma}{(1-\sigma)} s_g^{-1} + 1\right)}{\frac{1}{(1-\sigma)} - s_j\left(\frac{\sigma}{(1-\sigma)} s_g^{-1} + 1\right)} & if \quad j,k \in g \\ \dfrac{s_k}{\frac{1}{(1-\sigma)} - s_j\left(\frac{\sigma}{(1-\sigma)} s_g^{-1} + 1\right)} & if \quad j \in g, k \notin g. \end{cases}$$

A.3 Impact of A-380 Entry: Robustness Analysis

We have performed several robustness checks using different values for unobserved A-380 quality. Appendix table 1 and 2 consider the effect of A-380 entry under 10 and 20 percent price discounts assuming that the quality of A-380 is 10, 20 and 50 percent higher than the quality of A-340 and equal to the quality of 747 (about 70 percent higher than the quality of A-340). Let us focus on Appendix table 1. Unsurprisingly, as the A-380 quality increases, A-380 secures a bigger market share. While, Airbus sells 6 planes when the quality of A-380 equals the quality A-340 at 10 percent discounts, a 10, 20 and 50 percent higher quality yields 7, 8, and 11 sales, respectively. Moreover, Airbus would sell 15 A-380 if the quality of A-380 matched the quality of 747. Despite higher sales of A-380, we continue to find that A-380 not only negatively impacts 747 but also A-330 and A-340 and all the other characteristics of simulated results reported in table 6.

Table A.1--The effect of A380 entry at 10% discount and various quality assumptions

	No entry	1.1 A340		1.2 A340		1.5 A340		747	
	actual	simulated	change	simulated	change	simulated	change	simulated	change
Market Share									
Long Range									
A380		.0016		.0018		.0025		.0034	
747	.0120	.0120	.0000	.0120	.0000	.0119	.0000	.0119	-.0001
777	.0167	.0167	.0000	.0167	.0000	.0167	-.0001	.0166	-.0001
MD11	.0027	.0027	.0000	.0027	.0000	.0027	.0000	.0027	.0000
A330	.0052	.0051	-.0001	.0051	-.0001	.0050	-.0002	.0050	-.0002
A340	.0054	.0053	-.0001	.0053	-.0001	.0053	-.0002	.0052	-.0002
Medium Range									
767	.0106	.0106	.0000	.0106	.0000	.0106	.0000	.0106	.0000
A300	.0029	.0029	.0000	.0029	.0000	.0029	.0000	.0029	.0000
A310	.0002	.0002	.0000	.0002	.0000	.0002	.0000	.0002	.0000
Outside good	.9442	.9429	-.0013	.9427	-.0015	.9421	-.0021	.9414	-.0028
Market share within each wide-body market segment									
Long Range									
A380		.036		.040		.057		.075	
747	.285	.276	-.0090	.275	-.0101	.271	-.0143	.266	-.0190
777	.398	.385	-.0126	.384	-.0142	.378	-.0199	.371	-.0265
MD11	.065	.063	-.0020	.062	-.0023	.061	-.0032	.060	-.0043
A330	.124	.118	-.0060	.117	-.0068	.114	-.0095	.111	-.0125
A340	.129	.123	-.0063	.122	-.0071	.119	-.0099	.116	-.0130
Medium Range									
767	.771	.7706	.0001	.7706	.0001	.7706	.0001	.7707	.0002
A300	.213	.2130	-.0001	.2130	-.0001	.2130	-.0001	.2130	-.0002
A310	.016	.0164	.0000	.0164	.0000	.0164	.0000	.0164	.0000
Price (million 1995 $)									
Long Range									
747	146.8	146.5	-.2850	146.5	-.3193	146.3	-.4461	146.2	-.5893
777	107.6	107.3	-.2851	107.3	-.3194	107.2	-.4462	107.0	-.5894
MD11	101.8	101.5	-.2851	101.4	-.3194	101.3	-.4463	101.2	-.5895
A330	105.7	105.6	-.0821	105.6	-.0919	105.6	-.1278	105.6	-.1680
A340	112.8	112.7	-.0821	112.7	-.0918	112.6	-.1278	112.6	-.1680
Medium Range									
767	75.3	75.3	-.0077	75.3	-.0086	75.3	-.0122	75.3	-.0163
A300	82.6	82.6	-.0027	82.6	-.0030	82.6	-.0043	82.6	-.0057
A310	67.5	67.5	-.0027	67.5	-.0031	67.5	-.0043	67.5	-.0057
Number of A-380 sold		6.9		7.8		11.1		14.9	
Decline in sales of LR aircraft		1.2		1.3		1.9		2.6	
Decline in sales of MR aircraft		0.1		0.1		0.1		0.1	
Decline in sales of outside good		5.7		6.4		9.0		12.1	

Note: See notes to Table 6.

Table A.2--The effect of A380 entry at 20% discount and various quality assumptions

	No entry	1.1 A340		1.2 A340		1.5 A340		747	
	actual	simulated	change	simulated	change	simulated	change	simulated	change
Market Share									
Long Range									
A380		.0095		.0105		.0144		.0190	
747	.0120	.0117	-.0003	.0117	-.0003	.0115	-.0005	.0113	-.0007
777	.0167	.0164	-.0004	.0163	-.0004	.0161	-.0007	.0158	-.0010
MD11	.0027	.0027	-.0001	.0026	-.0001	.0026	-.0001	.0026	-.0002
A330	.0052	.0046	-.0006	.0046	-.0006	.0044	-.0008	.0042	-.0010
A340	.0054	.0048	-.0006	.0048	-.0006	.0046	-.0008	.0044	-.0011
Medium Range									
767	.0106	.0106	-.0001	.0106	-.0001	.0105	-.0001	.0105	-.0001
A300	.0029	.0029	.0000	.0029	.0000	.0029	.0000	.0029	.0000
A310	.0002	.0002	.0000	.0002	.0000	.0002	.0000	.0002	.0000
Outside good	.9442	0.9366	-.0076	0.9358	-.0084	0.9328	-.0114	.9296	-.0146
Market share within each wide-body market segment									
Long Range									
A380		.191		.209		.269		.328	
747	.285	.236	-.0491	.231	-.0538	.215	-.0701	.199	-.0863
777	.398	.329	-.0685	.323	-.0752	.300	-.0979	.277	-.1205
MD11	.065	.053	-.0111	.052	-.0122	.049	-.0159	.045	-.0195
A330	.124	.093	-.0303	.091	-.0330	.082	-.0417	.074	-.0499
A340	.129	.097	-.0317	.095	-.0344	.086	-.0435	.077	-.0520
Medium Range									
767	.771	.7709	.0005	.7710	.0005	.7712	.0007	.7713	.0008
A300	.213	.2127	-.0004	.2127	-.0005	.2125	-.0006	.2123	-.0008
A310	.016	.0164	.0000	.0164	.0000	.0163	.0000	.0163	-.0001
Price (million 1995 $)									
Long Range									
747	146.8	145.3	-1.4494	145.2	-1.5783	144.8	-2.0037	144.4	-2.4074
777	107.6	106.2	-1.4494	106.1	-1.5783	105.6	-2.0037	105.2	-2.4074
MD11	101.8	100.3	-1.4495	100.2	-1.5784	99.8	-2.0038	99.4	-2.4075
A330	105.7	105.3	-.4022	105.3	-.4362	105.2	-.5468	105.1	-.6492
A340	112.8	112.4	-.4022	112.3	-.4362	112.2	-.5468	112.1	-.6492
Medium Range									
767	75.3	75.3	-.0435	75.3	-.0479	75.3	-.0634	75.3	-.0794
A300	82.6	82.5	-.0145	82.5	-.0159	82.5	-.0207	82.5	-.0255
A310	67.5	67.4	-.0146	67.4	-.0160	67.4	-.0207	67.4	-.0255
Number of A-380 sold		41.9		46.6		63.7		82.5	
Decline in sales of LR aircraft		-8.1		-9.1		-12.9		17.2	
Decline in sales of MR aircraft		-0.4		-0.4		-0.6		0.7	
Decline in sales of outside good		33.4		37.1		50.2		64.6	

Note: See notes to table 6.