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Modelling strategic alliances in the wide-body long-range aircraft market

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Abstract

The wide-body long-range aircrafts market is characterized by increasing rivalry between Airbus and Boeing. One of the factors that drive their strategic behaviour is technological. We propose a technology indicator to identify conditions under which the aircraft companies have incentives to join a coalition. For this, we provide measurement of the side-payments necessary to sign a strategic alliance aimed at reducing technological barriers in the market. The results suggest that the existence of side-payments guarantees the stability of a strategic alliance if the gap in the technological level between the firms is high, or competition is through prices. For monopoly, a strategic alliance is profitable, but never stable.

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Keywords: Agreements; Aircrafts market; Competition; Technology barriers

1. Introduction

A close relationship exists between the technology and the strategic interactions of the aircraft firms. The aircraft industry is characterized by the rivalry between Airbus and Boeing and the adopting of mainly price-taker behaviour (Benkard, 2004; Esposito, 2004). However, both suppliers aim to monopolize the market by increasing the technological barriers over time. In fact, Boeing has monopolized the large long-range aircraft segment of the market for over 30 years with the B747 and, is developing the B787 to satisfy the preferences of the airlines that do not require a super speed aircraft, but a long-range, fuel efficient, low-cost machine capable of directly connecting any two cities in the world. Airbus aims to become the world leader by involving large Japanese companies (FHL, KHL and MHI) in the production of the A380—a plane of huge capacity—and the A350 aircraft—a direct competitor with the B787.

At the beginning of the 1960s, the technological growth in aviation was found in engine design as the piston engine gave way to the jet engine. This allowed aircraft with greater capacity and higher speeds. Innovations came with the introduction of new materials (ultralight alloys, carbon fibre), further developments in propulsion systems—high bypass ratios and use of electronics allowed fuel saving and improved reliability, safety, and speed (Cabral and Kretschmer, 2001). There were, however, trade-offs to be considered, for example, between speed and fuel consumption that involved technology choices.

To reduce technological barriers, aircraft manufacturers built up complex horizontal and vertical networks of relationships (Schmitt, 2000; Bonaccorsi and Giuri, 2001). For example, in the 1960s, projects for a supersonic transport aircraft became a reality because of two agreements. One was between British company Bristol Siddley and the French company Snecma to develop the Olympus Engine; the second was between the British Aerospace Corporation and the French company Sud Aviation-Société National de Constructions Aéronautiques to develop Concorde. More recently, new forms of cooperation between BAE Systems, Boeing, EADS and Lockheed Martin are emerging. This tendency towards horizontal relationships grows because the costs of developing new planes are so high but profit margins are low

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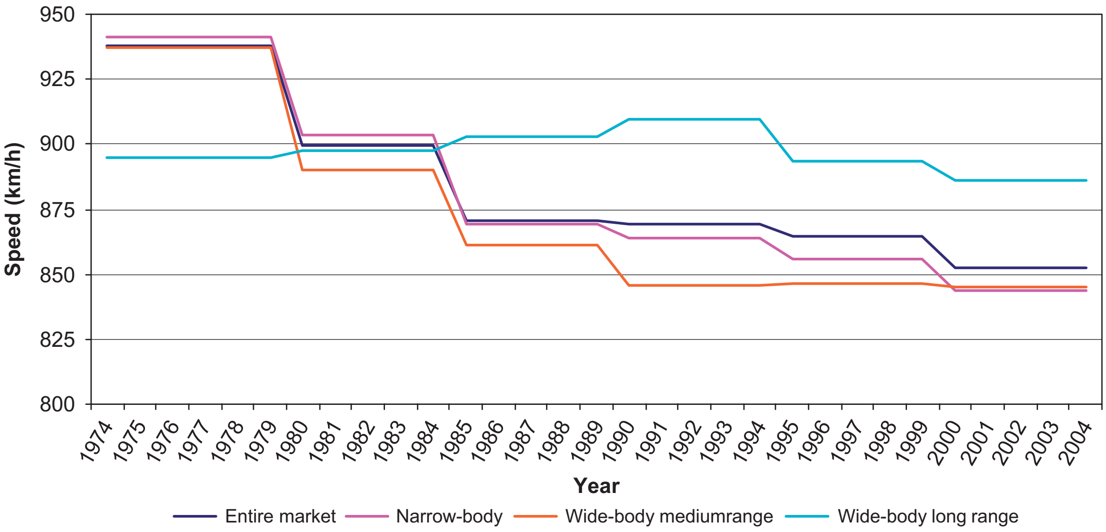

Fig. 1. Trend of the aircraft average speed.

requiring global markets for full cost recovery. According to Benkard (2004), prices are often below marginal costs. For example, Lockheed L-1011 had marginal costs higher than prices for 14 years, with resultant substantial financial loss for the manufacturer.

Vertical relationships are closely linked to technology levels. By investigating agreements between firms over aircrafts' production cycles for the last 50 years, Esposito shows that the higher the technology level, the larger is the number of vertical agreements. This is because that the higher the technology level involved, the greater are costs and thus the need to broaden market risk sharing.

Although there is a substantial literature that examines strategic behaviour of the aircraft producers (Pavcnik, 2002), it lacks analysis of how technological barriers affects strategic alliances. Here, we look at how technology levels affect agreements between Airbus and Boeing in the wide-body long-range market.[1] First, we develop a measure of technology on the basis of four parameters: maximum take-off weight, flight range, number of available seats, and direct operating costs. Furthermore, we define the unit cost function of the resultant technology index. This is used to discuss conditions where upon a strategic alliance would materialise and to define the size of the side-payment necessary to sign an agreement to reduce the technology barriers in the market.

2. Technology index

An aircraft's design is based on many parameters related to the different technological solutions (i.e. aircraft price, available seats, number and type of engines, maximum take-off weight, cruising speed, range, size, and operating costs). Unlike Esposito, we do not consider speed relevant to provide information on the aircraft's technological level, because the World Jet Inventory (2004) database from 1974 to 2004 shows a trend of cruising speed decreasing over time for all aircraft categories—narrow-body short range, wide-body medium and long range (Fig. 1). Initially, the increase in aircraft speed was due to the introduction of jet engines but since 1980, this parameter has assumed a secondary importance in the purchase choices of airlines. The strategy of the airlines is now based more on costs saving, notably fuel costs and direct operating costs saving, speed.

An index that focuses on the major improvements of the aircraft in relation to reductions in weight associated with using new materials (ultra light alloys, carbon fibre) can be defined as

$$IT_i = \sqrt{\left[\frac{\frac{MTOW_{\min}}{RANGE_{\min}\,SEAT_{\min}}}{\frac{MTOW_i}{RANGE_i\,SEAT_i}}\right]^2 + \left[\frac{UDOC_{\min}}{UDOC_i}\right]^2}, \qquad (1)$$

where for aircraft i, $MTOW_i$ is the maximum take-off weight, $RANGE_i$ is the flight range, $SEAT_i$ is the number of available seats and $UDOC_i$ are the unit direct operating costs. $MTOW_{\min}$, $RANGE_{\min}$, $SEAT_{\min}$ and $UDOC_{\min}$ are the minimums of the maximum take-off weight, flight range, number of available seats and unit direct operating costs across aircraft. Fig. 2 shows the index from 1974 to 2004 for the wide-body long-range aircrafts. The increasing trend is due to technical progress in aircraft construction materials.

3. Model

We define a specific form of firm conduct, without assuming the form of competition. Suppose that firm i maximizes its profits given by

$$\max_{q_i} \pi_i(q_i) = (p - c_i)q_i(p). \qquad (2)$$

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[1] We rely our analysis to the case of wide-body long-range aircrafts and to the rivalry between Airbus and Boeing, due to limits in data availability.

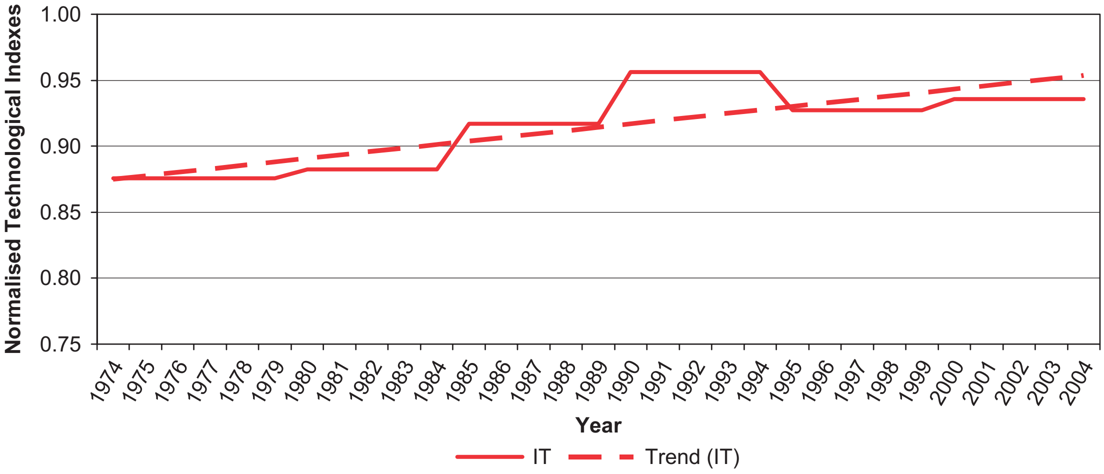

Fig. 2. Trend of the technological indexes for the wide-body long-range aircrafts.

In Eq. (2), p is the market price, $q_i(p)$ is the demand for the product, and c_i is the marginal cost of product $q_i(p)$. More specifically, the product demand of firm i is

$$q_i(p_i, p_j) = \Omega\left(\sum_{j \neq i} \sigma_{ij} p_j - p_i\right)^{\varepsilon}, \tag{3}$$

where σ_{ij} is a distribution parameter indicating the degree of substitutability between aircrafts i and j within the market. Furthermore, the market demand Q is

$$Q(p) = \sum_{i=1}^{n} q_i(p) = \Omega p^{\varepsilon}, \tag{4}$$

where ε is the demand elasticity and Ω is a constant parameter.[2]

Eq. (2) ideally requires information on unit cost of production c_i. Unfortunately, we do not have access to detailed cost data. Also, there is a lack of prior estimates of functional forms relating costs to technology levels in the aircrafts market. Thus, analysis is been based on a set of assumption:

$$c_i(IT_i) = IT_i^{\alpha_i}, \tag{5}$$

where IT_i is the technological level as defined in Eq. (1), and α_i a parameter. It follows that if the technology level of firm I's aircraft increases, its unit costs increase more rapidly if $\alpha_i > 0$.

We consider three market structures: duopoly (Cournot and Bertrand), monopoly and cooperation. These broadly represent how the aircraft industry has been characterized at various times. In fact, although there are may potentially be many aircrafts manufacturers, not only high technological barriers, but also substantial financial and market barriers, in the large aircraft market now limits it to two firms with monopoly within some segments. The equilibrium solutions seen in Table 1 are standard to economic theory, but the modelling framework allows isolation of situations under which an aircraft producer has an incentive to sign a strategic alliance to reduce barriers in the market.

Suppose there are two firms, each could seek to induce the other to sign a strategic alliance by offering side-payments. The level of these can be interpreted as a measure of the difficulty that will be encountered in reaching an agreement. The higher the side-payment, the higher are the barriers to agree. The side payment is an incentive to do *ex-ante* negotiations for a strategic alliance. Let T_i be the minimum non-negative payment to firm i necessary to make cooperation more attractive than any other market structure, that is if $\pi_{i,\text{coop}}{*}(\cdot) + T_i \geqslant \pi_{i,n}{*}(\cdot)$, we have

$$T_i = \max\{0, \pi_{i,n}(\cdot) - \pi_{i,\text{coop}}(\cdot)\}, \tag{6}$$

where $\pi_{i,\text{coop}}{*}$ and $\pi_{i,n}{*}$ are the profits with cooperation and the profits in any other market structure (e.g. a duopoly or monopoly), for firm i. The higher is T_i, the more difficulty it is to make an agreement.

A strategic alliance will take place if two conditions occur: profitability and stability. An agreement is profitable if each firm gains from joining the alliance, that is

$$\pi_{i,\text{coop}} + T_i \geqslant \pi_{i,n} \quad \forall i. \tag{7}$$

The side-payment may be zero for one firm, but not for both firms.

An agreement is stable if firm j has an incentive to transfer the side-payments to firm i, that is, if the willingness-to-pay by firm j for transferring the side-payment to firm i, defined as WTA_j, is greater than the side-payment to firm i:

$$WTA_j \geqslant T_i, \tag{8}$$

where

$$WTA_j = \pi^*_{j,\text{coop}}(\cdot) - \pi^*_{j,n}. \tag{9}$$

WTA_j may be zero for one firm, but not for both firms.

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[2] This formulation of market demand was used by Verleger (1972), Nero and Black (1998) and Carlsson (2002) to model air travel demand.

Table 1
Equilibrium solutions

	Price	Quantity	Profits
Monopoly	$P_m^* = \frac{\varepsilon c}{1+\varepsilon}$	$Q_m^* = \Omega\left(\frac{\varepsilon c}{1+\varepsilon}\right)^{\varepsilon}$	$\pi_m^* = -\Omega\left(\frac{c}{1+\varepsilon}\right)\left(\frac{\varepsilon c}{1+\varepsilon}\right)^{\varepsilon}$
Collusion	$P_{\mathrm{Coll}}^* = \frac{\varepsilon(c_i + c_{j\neq i})}{2(1+\varepsilon)}$	$Q_{\mathrm{Coll}}^* = \Omega\left[\frac{\varepsilon(c_i + c_{j\neq i})}{2(1+\varepsilon)}\right]^{\varepsilon}$	$\pi_{i,\mathrm{Coll}}^* = \frac{\Omega}{2}\left[\frac{\varepsilon(c_i + c_{j\neq i})}{2(1+\varepsilon)} - c_i\right]\left[\frac{\varepsilon(c_i + c_{j\neq i})}{2(1+\varepsilon)}\right]^{\varepsilon}$
Cournot duopoly	$P_{\mathrm{Cournot}}^* = \frac{\varepsilon(c_i + c_{j\neq i})}{1+2\varepsilon}$	$Q_{\mathrm{Cournot}}^* = \Omega\left(\frac{\varepsilon(c_i + c_{j\neq i})}{1+2\varepsilon}\right)^{\varepsilon}$	$\pi_{i,\mathrm{Cournot}}^* = -\varepsilon\Omega\left(\frac{\varepsilon(c_i + c_{j\neq i})}{1+2\varepsilon}\right)^{\varepsilon-1}\left(c_i - \frac{\varepsilon(c_i + c_{j\neq i})}{1+2\varepsilon}\right)^2$
Bertrand duopoly	$c_i < c_{j\neq i}\ P_{\mathrm{Bertrand}}^* = \frac{\varepsilon\lfloor(1+\varepsilon)c_i + \sigma c_{j\neq i}\rfloor}{(1+\varepsilon)^2 - \sigma^2}$	$Q_{\mathrm{Bertrand}}^* = q_i = \Omega\left\{\frac{\varepsilon[(1+\varepsilon)c_i + \sigma c_{j\neq i}]}{(1+\varepsilon)^2 - \sigma^2}\right\}^{\varepsilon}, q_{j\neq i} = 0$	$\pi_{i,\mathrm{Bertrand}}^* = \Omega\left\{\frac{\varepsilon[(1+\varepsilon)c_i + \sigma c_{j\neq i}]}{(1+\varepsilon)^2 - \sigma^2} - c_i\right\}\left\{\frac{\varepsilon[(1+\varepsilon)c_i + \sigma c_{j\neq i}]}{(1+\varepsilon)^2 - \sigma^2}\right\}^{\varepsilon}\ \pi_{j,\mathrm{Bertrand}}^* = 0$
	$c_i = c_{j\neq i} P_{\mathrm{Bertrand}}^* = \frac{\varepsilon(1+\varepsilon+\sigma)c_i}{(1+\varepsilon)^2 - \sigma^2}$	$Q_{\mathrm{Bertrand}}^* = \frac{q_i}{2} = \frac{q_{j\neq i}}{2} = \Omega\left\{\frac{\varepsilon[(1+\varepsilon+\sigma)c_i]}{(1+\varepsilon)^2 - \sigma^2}\right\}^{\varepsilon}$	$\pi_{i,\mathrm{Bertrand}}^* = \Omega\left\{\frac{\varepsilon(1+\varepsilon+\sigma)c_i}{(1+\varepsilon)^2 - \sigma^2} - c_i\right\}\left\{\frac{\varepsilon(1+\varepsilon+\sigma)c_i}{(1+\varepsilon)^2 - \sigma^2}\right\}^{\varepsilon}$
	$c_i > c_{j\neq i}\ P_{\mathrm{Bertrand}}^* = \frac{\varepsilon\lfloor(1+\varepsilon)c_{j\neq i} + \sigma c_i\rfloor}{(1+\varepsilon)^2 - \sigma^2}$	$Q_{\mathrm{Bertrand}}^* = q_j = \Omega\left\{\frac{\varepsilon[(1+\varepsilon)c_{j\neq i} + \sigma c_i]}{(1+\varepsilon)^2 - \sigma^2}\right\}^{\varepsilon}, q_i = 0$	$\pi_{j\neq i,\mathrm{Bertrand}}^* = \Omega\left\{\frac{\varepsilon[(1+\varepsilon)c_{j\neq i} + \sigma c_i]}{(1+\varepsilon)^2 - \sigma^2} - c_j\right\}\left\{\frac{\varepsilon[(1+\varepsilon)c_{j\neq i} + \sigma c_i]}{(1+\varepsilon)^2 - \sigma^2}\right\}^{\varepsilon}\ \pi_{i,\mathrm{Bertrand}}^* = 0$

4. Estimations

Our analysis is concentrated on wide-body long-range aircraft characterized by having a double aisle, a capacity of up to 550 passengers, and a range of up to 16,000 km; aircraft in this category are the Boeing 747, the Boeing 777, the Airbus 330 and the Airbus 340.

Demand in Eq. (4) is estimated using the data on prices and sales of 16 wide-body long-range aircraft (Tables 2 and 3).[3] We used the log–regression model:

$$\ln Q = \ln \Omega + \varepsilon \ln P + e, \tag{10}$$

where Ω is a constant term ε is the price coefficient, that in the log-model is also the demand elasticity, and $e \in (0,1)$ is a random error. The parameters Ω and ε are estimated using ordinary least squares (OLS). We find Ω is 1.78×10^9 and ε is -3.18. The estimates of price elasticity confirm previous results for the wide-body long-range market.[4] The explanatory power of the model is not exceptional, with a coefficient of determination of 0.43. However, given the volatility of the aircraft market and the difficulty in collecting data, this relatively low value is acceptable; the 95% confidence interval of the *F*-test provides further confidence that the regression estimates are statistically significant as a whole. Furthermore, the degree of substitutability between aircrafts in Eq. (3) has been set equal to 0.45 (Irwin and Pavcnik, 2004).

The technology levels (IT) for Airbus and Boeing are calculated collected using data on price, maximum take-off weight, flight range, number of available seats, and unit direct operating costs, with 12 observations for any producer. IT is equal to 0.88 for Airbus and 0.98 for Boeing.

Finally, we test the sensitivity of the results for the range $0.7 \leqslant IT \leqslant 1.2$ and for $\alpha_i \in [-3, 3]$; these can be considered plausible parameters for the unit costs function in Eq. (5).

5. Simulation results

The aircraft industry has been more and more characterized by rivalry between Airbus and Boeing. Figs. 3 and 4 show the two firms' profits under various duopoly models. For many values of α, competition in quantity is more apparent than competition in prices. This is confirmed by sensitivity analysis of the technology index, reported in Figs. 5 and 6. As the technology index increases, and for the highest values of α, profits are almost insensitive as to whether firms compete in prices or quantities. This is because costs increase rapidly and, hence, in Cournot duopoly the profits converge to zero, whereas, in Bertrand duopoly the firm with the highest costs makes zero profits.

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[3] Price data are from the magazine Airline Fleet & Network Management, and quantity data from World Jet Inventory (2004) database.

[4] See for example Irwin and Pavcnik (2004) for rigorous estimates of price elasticities.

Table 2
Average values of deliveries for wide-body long-range segment (1989–2004)

Year	Deliveries	Price ($millions)	MTOW (kg)	Capacity (No. of pax)	Range (km)	UDOC ($/km × pax)	NIT
1989	45	216.00	382,197	444	12,850	0.0340	0.953
1990	73	213.42	377,983	440	12,857	0.0341	0.952
1991	95	195.51	351,209	408	13,057	0.0349	0.949
1992	103	190.39	349,084	419	13,275	0.0346	0.975
1993	115	180.57	335,528	390	13,426	0.0354	0.949
1994	91	175.43	325,282	375	13,274	0.0359	0.931
1995	105	165.99	289,040	355	12,192	0.0369	0.911
1996	111	170.71	292,375	360	12,210	0.0367	0.910
1997	157	176.78	300,877	367	12,752	0.0363	0.936
1998	186	183.63	307,016	386	12,563	0.0357	0.952
1999	202	180.02	296,493	377	12,345	0.0361	0.946
2000	146	173.14	285,429	362	12,284	0.0366	0.933
2001	151	177.05	292,409	369	12,375	0.0363	0.939
2002	132	177.28	295,864	369	12,498	0.0363	0.940
2003	122	173.96	299,605	358	12,950	0.0366	0.931
2004	126	171.45	292,101	345	12,883	0.0371	0.919

Table 3
Aircrafts for wide-body long-range segment

Aircraft	Entry year	Price 2005, ($$10^6$)	MTOW (kg)	Capacity (no. of pax)	Range (km)
A300B4-600	1984	117	165,900	266	7600
A310	1983	92.3	157,000	220	8825
787-3	2010	130	163,296	296	6500
767		133.25	190,057	262	11,328
767-200ER	1982	118.3	179,170	232	12,223
767-300ER	1986	134.8	186,880	279	11,306
767-400ER	2001	146.6	204,120	274	10,454
MD-11	1990	153.2	279,651	344	13,020
A330		138.8	231,500	294	11,500
A330-300	1993	144.4	231,500	315	10,500
A330-200	1998	133.2	231,500	273	12,500
A340		156.55	325,188	307	14,744
A340-200	1993	135.4	275,000	239	14,800
A340-300	1993	138.2	275,750	295	13,525
A340-500	2002	176.3	376,000	313	16,400
A340-600	2002	176.3	374,000	380	14,250
777		208.7	308,263	373	13,407
777-200	1995	180	247,210	372	9649
777-200ER	1997	191.4	297,560	370	14,316
777-300	1998	212	297,560	456	11,029
777-300ER	2004	239.5	351,534	365	14,594
777-200LR	2006	220.5	347,452	301	17,446
747		219	404,833	470	13,827
747-400	1989	216	396,890	470	13,450
747-400ER	2002	223	412,775	470	14,205
A380	2006	282.1	560,000	555	15,000
787-8	2008	130	217,728	223	15,700

However, there may be situations in which one of the firms would gain through cooperation rather than in competitive duopoly. From the Cournot solution, a strategic alliance is profitable without side-payments for Airbus if $\alpha < 1$ and for Boeing if $\alpha > -0.5$ (Figs. 7 and 8). If there are side-payments the agreement is always profitable. But the strategic alliance is stable only for $-1 \leqslant \alpha \leqslant 1$ (Fig. 9). Table 4 shows that if one of the firms decreases its IT, the strategic alliance is stable for $\alpha < 0.5$. Summarizing, the larger the gap between the technology index of the two firms and thus the larger the gap in the costs between the firms, the more an agreement will be stable if there are side-payments.

From the Bertrand solution, a strategic alliance is profitable without side-payments for Airbus if $\alpha \leqslant 0$ and for Boeing if $\alpha > 0$ (Figs. 7 and 8). If there are

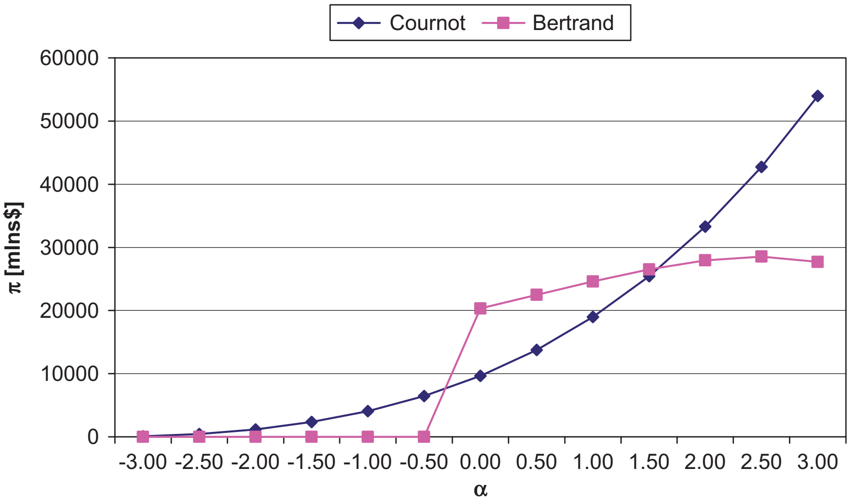

Fig. 3. Airbus's profits in duopoly.

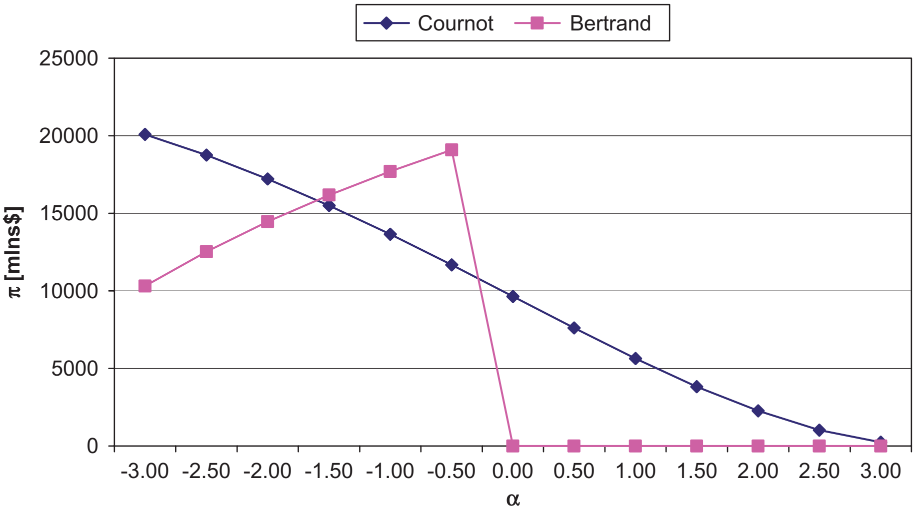

Fig. 4. Boeing's profits in duopoly.

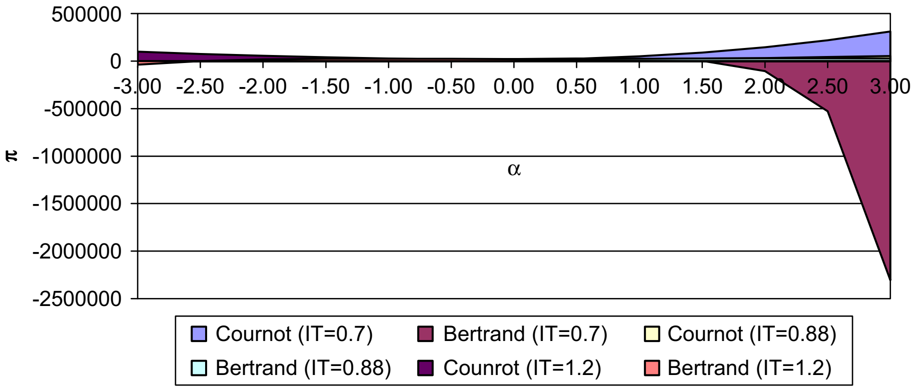

Fig. 5. Sensitivity analysis of Airbus's profits (duopoly).

side-payments the agreement is not only profitable, but also stable for any value of α (Fig. 10) This result is confirmed if the technology index changes (Table 5). Again the intuition of these results is seen through the difference in the costs of the two firms. In the Bertrand solution, if the differential in costs is small, the solution approximates competition and the size of the side-payments approximates zero. If the costs differential is high, the firm with

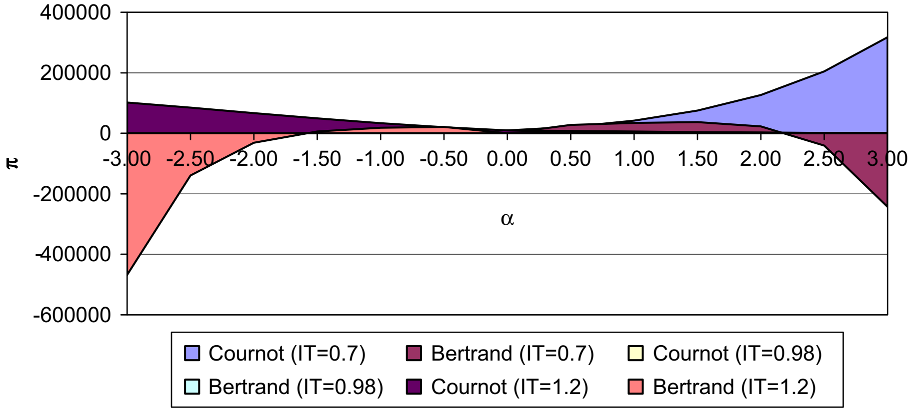

Fig. 6. Sensitivity analysis of Boeing's profits (duopoly).

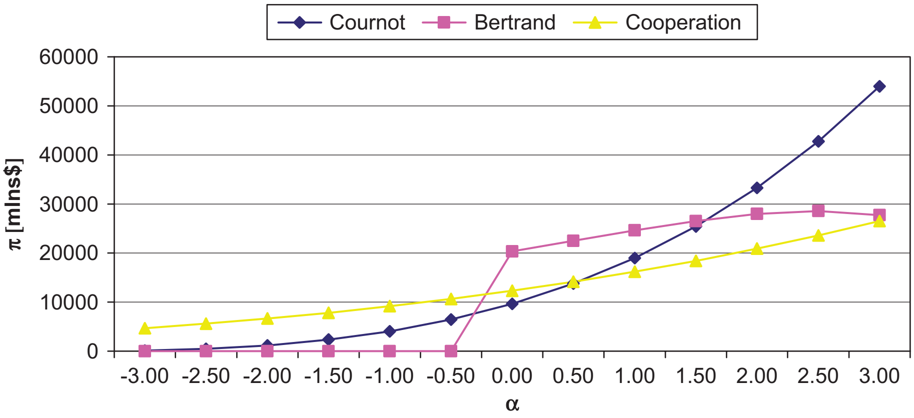

Fig. 7. Cooperation versus duopoly: Airbus.

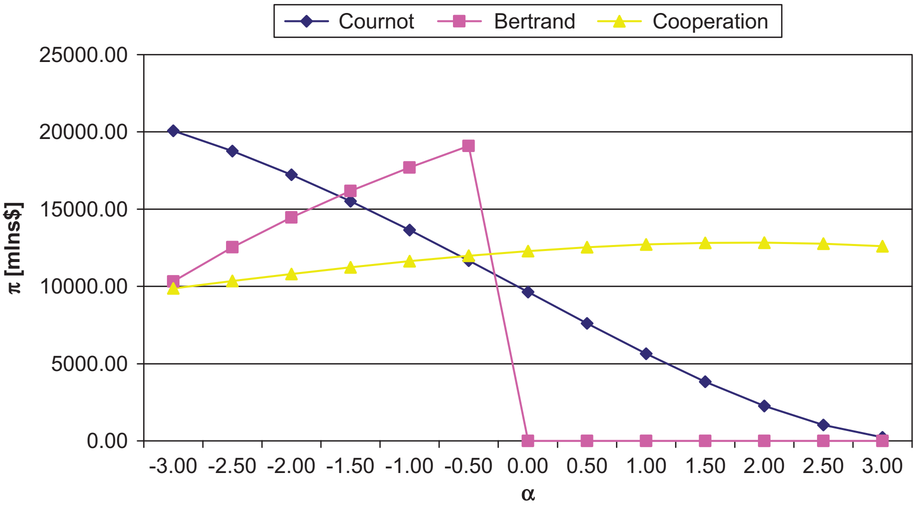

Fig. 8. Cooperation versus duopoly: Boeing.

the highest costs makes zero profits, although if an agreement is reached profits become positive. Thus, through side-payments, reflecting the differential in profits, it can always stimualte the other firm to sign an agreement.

But both Airbus and Boeing have sought to monopolize the market rather than to engage in a strategic alliance; this because both would gain more individually if they were a monopoly than in a competitive duopoly or with cooperation. This result is straight from economic theory, but one question that arises concerning the way side-payments may act to deter a strategic alliances from leading to a monopoly. Figs. 11 and 12 show that the existence of

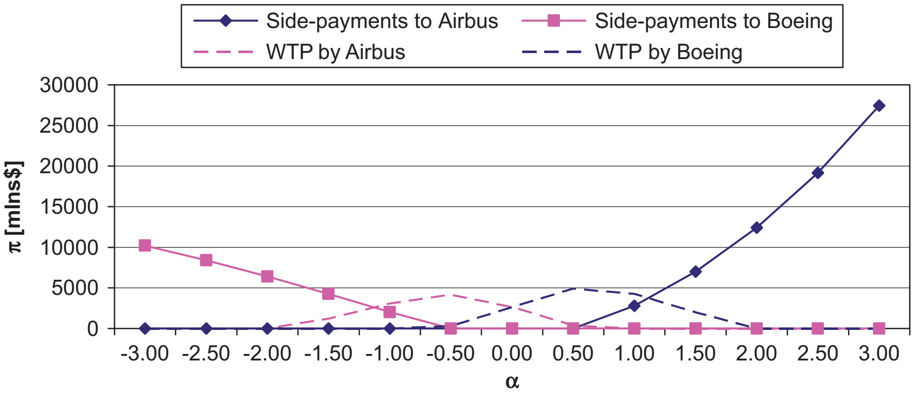

Fig. 9. From Cournot duopoly to agreement.

Table 4
Side-payments for strategic alliances from Cournot duopoly

IT	Airbus			Boeing		
α	0.7	0.88	1.2	0.7	0.98	1.2
−3.00	39 (596)	0 (0)	67,756 (0)	0 (0)	10,210 (0)	78,795 (0)
−2.50	0 (1195)	0 (0)	48,474 (0)	0 (491)	8407 (0)	62,849 (0)
−2.00	0 (2071)	0 (0)	32,343 (0)	0 (1406)	6418 (0)	46,332 (0)
−1.50	0 (3362)	0 (0)	19,343 (0)	0 (2860)	4275 (1207)	30,444 (0)
−1.00	0 (4498)	0 (0)	9342 (0)	0 (4961)	2015 (3071)	16,372 (0)
−0.50	0 (4653)	0 (313)	2113 (0)	0 (5752)	0 (4181)	5119 (0)
0.00	0 (2651)	0 (2651)	0 (2651)	0 (2651)	0 (2651)	0 (2651)
0.50	6957 (0)	0 (4931)	0 (6700)	3319 (0)	0 (369)	0 (5313)
1.00	25,985 (0)	2802 (4270)	0 (7233)	15,891 (0)	0 (0)	0 (6267)
1.50	57,288 (0)	7009 (1979)	0 (5295)	38,738 (0)	0 (0)	0 (5909)
2.00	103,266 (0)	12,408 (0)	0 (3354)	76,786 (0)	0 (0)	0 (4655)
2.50	165,507 (0)	19,164 (0)	0 (1709)	136,447 (0)	0 (0)	0 (3383)
3.00	244,557 (0)	27,445 (0)	0 (378)	225,836 (0)	0 (0)	0 (2335)

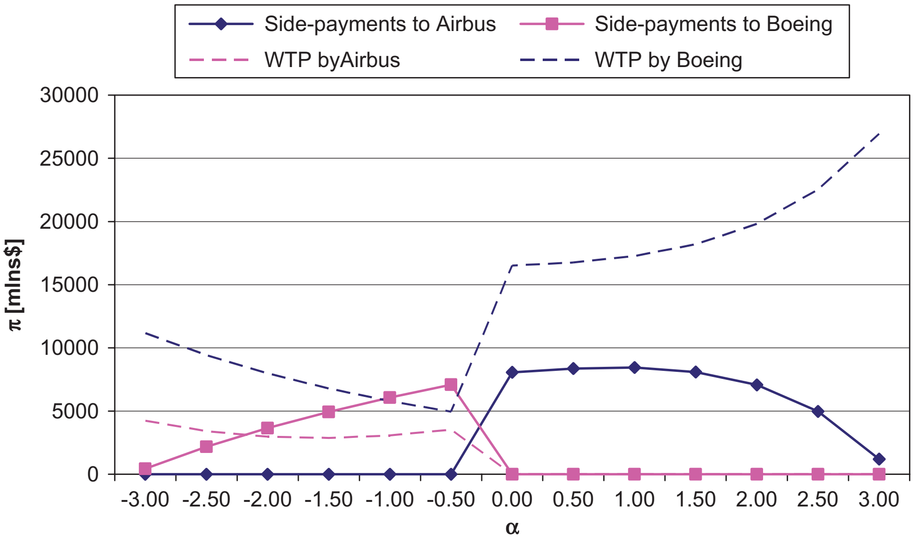

Fig. 10. From Bertrand duopoly to agreement.

side-payments would increase the profitable of an alliance, but it is instable, because the willingness-to-pay by each firm is lower than the size of the side-payment claimed by the other which is monopolist. The same result occurs applying the sensitivity analysis to the technology index.

If the firms compete on quantity, the main factor that guarantees the stability of any agreement is that the gap in

Table 5
Side-payments for strategic alliances from Bertrand duopoly

IT	Airbus			Boeing		
α	0.7	0.88	1.2	0.7	0.98	1.2
−3.00	39 (2346)	0 (11,158)	0 (54,9185)	0 (0)	445 (4240)	0 (69,291)
−2.50	0 (3518)	0 (9431)	0 (205,694)	0 (491)	2183 (3418)	0 (26,869)
−2.00	0 (5190)	0 (7998)	0 (85,776)	0 (1406)	3659 (2982)	0 (6674)
−1.50	0 (7656)	0 (6800)	2632 (35,694)	0 (2860)	4938 (2881)	0 (0)
−1.00	0 (11,294)	0 (5794)	6580 (11,341)	0 (5033)	6071 (3074)	1707 (0)
−0.50	0 (16,661)	0 (4946)	7927 (702)	0 (8114)	7100 (3530)	6659 (0)
0.00	8061 (16,516)	8061 (16,516)	8061 (16,516)	0 (0)	0 (0)	0 (0)
0.50	7694 (1341)	8372 (16,765)	0 (20,148)	9284 (0)	0 (0)	0 (9981)
1.00	561 (18,896)	8441 (17,268)	0 (16,517)	8356 (0)	0 (0)	0 (7942)
1.50	0 (42,389)	8096 (18,198)	0 (13,540)	415 (30,596)	0 (0)	0 (6170)
2.00	0 (93,879)	7075 (19,818)	0 (11,100)	0 (148,086)	0 (0)	0 (4655)
2.50	0 (212,654)	4976 (22,529)	0 (9099)	0 (581,561)	0 (0)	0 (3383)
3.00	0 (496,592)	1197 (26,934)	0 (7459)	0 (2370,955)	0 (0)	0 (2335)

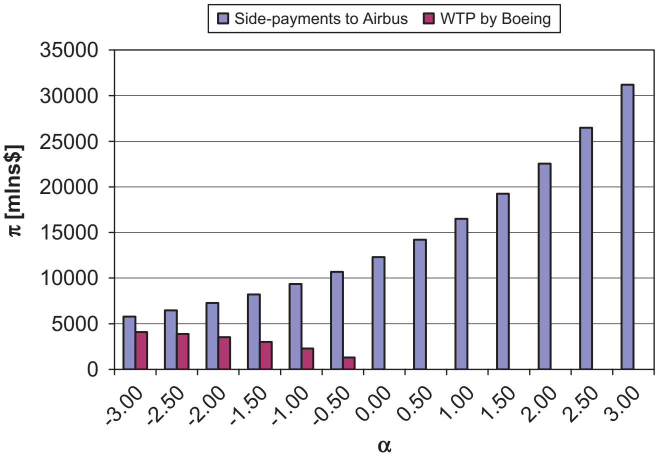

Fig. 11. From monopoly by Airbus to agreement.

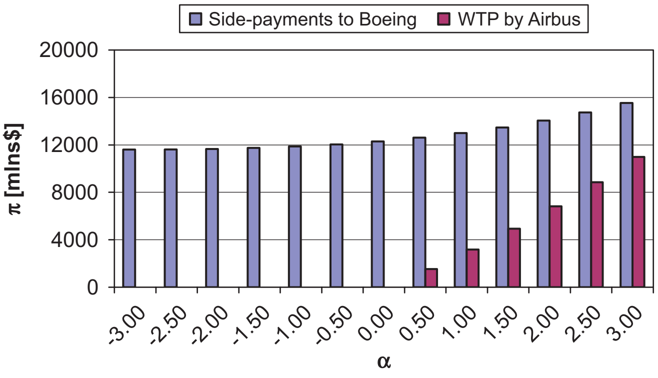

Fig. 12. From monopoly by Boeing to agreement.

the technology level between the two firms is large. For monopoly, the existence of side-payments does not guarantee the stability of the alliance.

6. Conclusions

Our analysis has focused on the rivalry between Airbus and Boeing in the wide-body long-range airline market segment. But the results are striking. It has been shown that speed is not a relevant parameter in technical consideration, but other parameters, such as maximum take-off weight, are more relevant. This confirms the strategy adopted by Boeing in its production of the B787 that aims to satisfy the needs of airlines that do not require a super speed aircraft, but rather seek a single, cost efficiency aircraft that can to connect cities everywhere in the world without the need to use congested hubs.

Furthermore, there are conditions under which the firms may find it profitable to sign a strategic alliance that ends up being stable. The existence of side-payments guarantees that such agreements are profitable for the manufacturers involved. Stability occurs if the agreement emanates from competition, for example, from Bertrand duopoly, but is not guaranteed if the agreement comes from monopoly.

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