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"Airbus vs. Boeing in Super Jumbos: A Case of Failed Preemption"

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Abstract

This paper looks at competitive interactions between Airbus and Boeing in very large aircraft. It concludes that Boeing attempted to preempt Airbus in introducing a new product in this space but failed to do so because of the incredibility, given the assumption of value maximization, of self-cannibalization. A theoretical model is used to illustrate this credibility constraint, and an assortment of evidence—involving pro forma financial valuations, product market data (on prices and quantities), capital market reactions to key events, and qualitative information on Boeing's organizational structure and recent changes to it—is assembled to support the hypothesis that the constraint on self-cannibalization ultimately proved decisive.

I. Introduction

In December 2000, Airbus formally committed to spend $11.9 billion to develop and launch a 555-seat superjumbo plane known as the A380. Prior to Airbus' formal commitment, Boeing had started an initiative to develop a "stretch jumbo" with capacity in between its existing jumbo (the 747) and Airbus' planned superjumbo, had stopped the effort, and then had restarted it. After Airbus' formal commitment, Boeing cancelled the stretch jumbo for the second (and apparently final) time.

It is worth digging deeper into this case, for at least two sets of reasons. First, the superjumbo is a strategic commitment of more than average interest because of its sheer size, irreversibility and potential impact on industry structure. The superjumbo represents one of the largest product launch decisions in corporate history given Airbus' projected launch cost of $11.9 billion (a figure that also represented 26% of total industry revenues—$45.6 billion—and more than 70% of Airbus' total revenues—$17.2 billion—in 2000).[1] The riskiness of expenditures of this magnitude is magnified by the fact that Airbus has to spend essentially the entire amount before it makes its first delivery, in an industry in which many firms—e.g., Glenn Martin, General Dynamics, and, more recently, Lockheed—failed as a result of bet-the-company product development efforts. If, however, the launch succeeds, Airbus is expected to dislodge Boeing as the market leader in commercial aircraft after more than 40 years of market dominance by the latter. The incidence of "sporty bets," to use a term popularized by John Newhouse (1982) in his book on the industry in general and the launch of the Boeing 747 in particular, suggests that the commercial aircraft industry may, more than most, be one in which outcomes are largely determined by a few strategic commitments.

Second, the case of the stretch/superjumbo happens to share some key structural features with stylized game-theoretic models of preemption. There were only two competitors in the market for large aircraft and therefore two potential entrants, realistically, into the emerging niche for very large aircraft (or VLA, defined as aircraft seating more than 400 passengers in the standard configuration).[2] Competitors' moves were clearly delineated by technological lumpiness, and exhibited strategic interdependence: thus, it seemed clear that if each competitor developed a brand new

VLA, both would incur very large losses and that intense competition in the pricing of VLA would increase pricing pressures on Boeing's 747 as well. Given these considerations, one might go so far as to call the battle over the VLA market segment a "critical" case study for game theoretic models of preemption through product innovation.

This paper presents a game-theoretic analysis of Airbus' commitment to the superjumbo and Boeing's failure to commit to either the superjumbo or the stretch jumbo. Specifically, one particular line of game-theoretic modeling offers the nonobvious insight that although the incumbent, Boeing, would earn higher operating profits if it could somehow deter the entrant, Airbus, from developing a superjumbo, entry-deterrence through new product introductions may be incredible even if the incumbent enjoys large cost advantages in new product development (e.g., because of line-extension economies). It turns out to be easy to set up simple game-theoretic models in which preemption by the incumbent is incredible *even if it can innovate at zero costs*, unlike the entrant!

Interactive effects of the sort highlighted by the game-theoretic self-cannibalization constraint turn out not only to be sufficient to explain the launch/nonlaunch outcomes observed in the case of the superjumbo but, in some respects, essential as well. Various alternate explanations—that Airbus' commitment to the superjumbo was driven by (greater) subsidies, that Boeing was deterred by the Asian crisis from launching a stretch jumbo, and even that Boeing somehow fooled Airbus into doing exactly what Boeing wanted—are considered and rejected to varying degrees in the empirical sections of this paper. Given the variety of explanations entertained, a wide array of evidence—including pro forma financial valuations, product market data (on initial prices and quantity forecasts), capital market reactions to key events, and qualitative information on Boeing's organizational structure and recent changes to it—has to be considered. As a result, we find it efficient to organize the empirical sections of this paper by type of evidence.

To provide an overview of the paper, we focus our analysis of product-line interactions in the VLA segment on two key questions. First, why did Airbus, not Boeing, launch the superjumbo? And second, why did Boeing's efforts to launch an intermediate "stretch jumbo" falter? Section II provides background information on the

commercial aircraft industry, the two major competitors in it, and the state of play between them in very large aircraft as of mid-2001. Section III presents some proforma financial analyses of the superjumbo that helps establish, among other things, that there was room for at most one new product of this type. Section IV maps Airbus and Boeing's interactions on to a set of considerations that are, according to simple game-theoretic models, influential in determining whether an incumbent (read Boeing) can crowd out a possible entrant (read Airbus) by developing a new product. Sections V through VII look, respectively, at (additional) product market, capital market and internal organizational evidence that the strategic or interactive effects flagged by the game-theoretic models actually loomed large in Boeing and Airbus' interactions in very large aircraft. Section VIII concludes.

II. Case Background[3]

With total sales of $45.6 billion in 2000, the manufacture and sale of jet aircraft is the biggest single segment of the $140 billion commercial aviation industry. Two firms, The Boeing Company and Airbus Industrie, dominate the manufacture of large commercial aircraft. Combined, they delivered 790 aircraft in 2000, ranging from single-aisle jets seating 100-200 passengers to the twin-aisle Boeing 747-400 seating more than 400 passengers. **Figure 1** maps Boeing's and Airbus' product lines along the two primary dimensions of capacity (number of seats in the standard configuration) and range (in statute miles). Obviously, the two dimensions are highly collinear, and VLA are situated at the large/long-range end of the industry product line-up. Looking at one end of the product range makes it more plausible to focus on a particular market segment, i.e., to concentrate on localized competition among a small number of products, than if one were looking at the middle of the product range. The very large end is particularly congenial analytically since at the small end, competition from regional jet manufacturers expanding beyond their sub-100 seat niche would also have to be taken into account. In contrast, the very large end does have just two competitors, sidestepping extreme sensitivity to the impact of two versus three competitors that calibrated simulation models of the industry can exhibit (e.g., Neven and Seabright [1995] vs. Klepper [1990]).

Place Figure 1 approximately here

To begin our narrative at the company level, Boeing has been at the forefront of civil aviation for over 40 years. From the B17s and B29s of World War II through the B52s of the Cold War, it has leveraged its manufacturing and defense experience to become the world's leading producer of commercial aircraft. Boeing's commercial fleet consists of 14 models spread across 5 aircraft families. It has built approximately 85% of the industry's current fleet and, until recently, regularly captured 60-80% of orders and deliveries. The flagship of the Boeing fleet, the 747-400, holds 412 passengers in the standard three-class configuration and as many as 550 in certain "high-density," all-coach configurations used mainly on Asia routes. More than three decades after the jumbo was introduced, demand for it remains strong. Boeing delivered 25 747's in 2000, down from 47 planes in 1999, and had an order backlog for 80 more.[4] At the corporate level, Boeing had revenues of $51.3 billion, net income of $2.1 billion, an equity market capitalization of $58 billion, and 198,000 employees at year-end 2000. Sales of commercial aircraft generate almost two-thirds of total revenue while sales of military aircraft, missiles, and space systems account for the rest. In addition to being the US government's second largest defense contractor, Boeing was also the largest single US exporter.

The other major competitor, Airbus Industrie, was founded in 1970 as a consortium of the principal aerospace companies of Germany (Deutsche Aerospace, now a Daimler-Chrysler subsidiary known as DASA), France (Aerospatiale Matra), England (Britain's Hawker Siddeley, later BAE Systems), and Spain (Construcciones Aeronauticas, CASA). Airbus has a fleet of nine basic models, a customer base of 171 operators, and an order backlog for 1,445 planes. All of its planes employ "fly-by-wire" technology that substitutes computerized control for mechanical linkages between the pilot and the aircraft's control surfaces. This technology combined with a common cockpit design help explain why Airbus received over half the *orders* for large aircraft for the first time in 1999, even though its share of deliveries was only 33% by number and 30% by value that year. Despite the gains in market share, Airbus still does not have a

jumbo jet to compete with Boeing's 747 in the VLA market. A senior executive at Aerospatiale complained: "The problem is the monopoly of the 747, which is a fantastic advantage. They have a product. We have none."[5]

In the early 1990s, Airbus and Boeing independently began to study the feasibility of launching a superjumbo capable of holding 500 to 1000 passengers. Both agreed there was a growing need for a superjumbo because of increasing congestion at major hubs like New York, Los Angeles, London, and Tokyo. Alternatives to larger planes were seen as either infeasible, in the case of greater flight frequency, or ineffective, in the case of flights to secondary airports. What there seems to have been greater agreement about was the idea that there was room in the market for at most one competitor.[6]

Over this period, there also appears to be an interesting attempt at preemption involving private negotiations between Boeing and select Airbus members. Prior to joining forces with Airbus to explore the possibility of collaborating on a new superjumbo, Boeing secretly and separately approached Daimler Benz AG and British Aerospace PLC about the possibility of joining forces on a superjumbo jet. According to European news reports, subsequently denied by spokesmen from both Boeing and Airbus, Boeing invited Daimler-Benz and British Aerospace to collaborate in a joint venture.[7]

In the aftermath of such denials, Boeing and Airbus agreed to collaborate on a joint feasibility study for a VLA that could hold from 550 to 800 passengers. When the collaboration began in January1993, they envisioned the plane would cost $10 to $15 billion to develop (with estimates ranging from $5 to $20 billion) and would sell for $150 to $200 million each. Their preliminary demand estimate was reported to be 500 planes over the next 20 years.[8]

In July 1995, however, the collaboration ended. An Airbus employee cynically noted that Boeing's participation in the joint effort may have been only to "…stall the market so that Airbus did not develop anything itself."[9] Such inferences were bolstered by Boeing's apparent use of "cooperative" ventures to forestall competition in other situations. Cited particularly frequently in this context is Boeing's participation, in the 1980s, as the foreign partner in a Japanese project to develop a 150-seat passenger aircraft that it delayed and allegedly helped derail.[10]

According to an industry analyst, much of the disagreement between Boeing and Airbus in their joint feasibility study of the VLA concerned—as theoretical models of the sort developed in the next section would predict—the new plane's capacity:

> Strategic competitive considerations were also a factor for Boeing and for the Airbus members. Seattle-based Boeing didn't want the super-jumbo jet to carry fewer than 600 passengers, so that it could preserve the market for any expanded version of its 747 jumbo jets, which have a current maximum capacity of 420 seats…Some Airbus members wanted any joint US-European line of superjumbo jets to begin with a 500-seat version to prevent Boeing from increasing its own overall share of all airliner markets.[11]

The two firms also disagreed at a fundamental level about future demand dynamics. Boeing maintained that increased fragmentation in the form of point-to-point travel would solve the problem of congestion at major airports. Airbus, on the other hand, believed that hub-to-hub travel, particularly at the major airports in London, New York, Los Angeles, and Tokyo would continue to grow. While it agreed with Boeing that some increases in fragmentation and frequency would occur, it did not believe that they represented long-term solutions to increasing travel, especially at major hubs in Asia. As a result, Airbus saw the development of airplanes with greater capacity as essential.

At any rate, once their collaboration ended, both competitors reverted to independent efforts in this product space. Airbus quickly set up a Large Aircraft Decision to pursue the market opportunity in VLA. And for its part, Boeing considered two updated and "stretched" versions of its popular 747 jumbo jet, the 747-500X holding up to 490 passengers and the 747-600X holding up to 550 passengers, at a total cost of $5 to $7 billion.[12] Although analysts expected Boeing to announce the new planes at the Farnborough Air Show in September 1996, it did not. In fact, Boeing *never* formally announced it was going to develop the stretch jumbo yet did, in January 1997, announce it was canceling the development effort.[13] Less than three years later, however, in September 1999, Boeing reversed course once again and now said it was going to build a

stretch jumbo at a cost of $4 billion. The 747X-Stretch was supposed to hold up to 520 passengers and, according to Boeing, would be available by 2004, two years ahead of Airbus' A380. At the time, Boeing forecast demand for 600 planes, comprised of 330 passenger and 270 cargo aircraft, in this size category by 2019.

Concurrently, Airbus forged ahead with development of a superjumbo jet and finalized plans in 1999 to offer a family of very large aircraft. The first model, the A380-100, would seat 555 passengers in the standard three-class configuration and could provide non-stop service from Sydney to Los Angeles, Singapore to London Heathrow, or New York to Tokyo, the same routes currently served by Boeing's jumbo. A second passenger model, the A380-200, would seat 650 passengers in the three-class configuration and up to 990 in an all-economy version. Airbus also planned to build a freighter version, the A380-800F, capable of carrying up to 150 tons of cargo. Although the increase in size relative to Boeing's 747 appears large, Airbus has argued that it represents a smaller relative increase over the 747 than Boeing's 747 was over the next largest plane when it was introduced in 1969: the A380 is 35% larger than the 747, while the 747 was 150% larger than the 707.[14] In terms of pricing, the A380's list price is significantly higher than the 747's list price, $220 million vs. $185 million, yet Airbus claims the combination of increased capacity and reduced operating costs provides superior economics. According to company documents, the operating cost per flight will be 12% more than the 747's cost, but given the plane's 35% greater capacity, it will provide almost 25% more volume for free.[15]

Developing the first passenger model and the freighter version of the superjumbo is expected to cost $10.7 billion, paid through $2.5 billion of "launch aid" from European governments), $3.1 billion of risk sharing capital from suppliers like Saab, and $5.1 billion of equity from Airbus Industrie. In addition, Airbus forecasts a need for an additional $1.2 billion of capital expenditures bringing the total development and launch cost to $11.9 billion.

Between June 2000, when the Airbus supervisory board gave approval to begin marketing the plane, and December 2000, airlines placed orders for 50 superjumbos and bought options on another 42 planes. With these orders in hand, including a number from important 747 customers such as Singapore Airlines and Qantas Airlines, the Airbus

board officially launched the new plane.[16] According to its internal projections, Airbus forecast a need for 1,500 planes of this size over the next 20 years, expected to capture up to half the market, and earn pre-tax margins of 20%.[17] In addition, Airbus estimated it would break even with sales of 250 planes (on an accounting, but not cash flow basis) and would have 100 firm orders by the end of 2001.[18] As of early 2002, Airbus had 97 orders and 41 options for the A380.[19]

On March 29, 2001, Boeing announced it was curtailing development of its stretch jumbo and would begin development of a new aircraft known as the Sonic Cruiser. This plane would fly faster (Mach 0.95 vs. Mach 0.80), higher, and more quietly than existing aircraft. It would also be significantly smaller than the stretch jumbo (200 passengers vs. 520 passengers), though it would cost more to develop ($9 billion vs. $4 billion). The Sonic Cruiser is not only more consistent with Boeing's predictions regarding industry evolution towards greater point-to-point travel, but also adds a third dimension—speed—to the capacity/range product space.

The terrorist attacks of September 11, 2001 and the attendant drop in air travel exerted significant pressure on both Boeing and Airbus' parent, EADS. Boeing, in particular, announced significant job cutbacks, of 30,000 people from a workforce of 92,000 in commercial airplanes. Both stocks also came under pressure: as of early February 2002, Boeing was down by 5% and EADS, Airbus' parent, by nearly 20% from their closing prices on September 10, 2001. As of early 2002, the superjumbo program is on track, helped by an expanded order from Emirates Airlines making it the largest projected customer for the plane (interestingly, it also expressed an interest in Boeing's planned Sonic Cruiser).[20] With that update, the analysis that follows is set, unless otherwise noted, as of the middle of 2001.

The focus in the present analysis on competitive maneuvering around a particular strategic commitment obviously differs from that adopted in broader analyses by economists of the evolution of the commercial aircraft industry as a whole. Although the industry is long been invoked as an example in the context of strategic trade policy (e.g., Dixit and Kyle [1985]), the two most influential recent strands of empirical research in it have been supplied by work that calibrates and runs simulation models of the industry (e.g., Baldwin and Krugman [1987], Klepper [1990] and Neven and Seabright [1995])

and, more recently, work that uses discrete choice random utility models to infer the structure of the demand for differentiated airplane offerings and, given auxiliary assumptions about product market competition, price-cost markups (e.g., Benkard [2000], who manages to incorporate elements of industry simulation into his analysis as well, and Irwin and Pavcnik [2001], who use a richer demand structure). Such work complements but does not substitute for detailed analysis of a particular strategic commitment: the latter can be presumed to have some distinctive value, at least in an industry judged earlier to come closer than most to the stylization of being largely driven by the outcomes to a limited number of strategic commitments.

As a result, the present analysis resembles Porter and Spence's [1982] classic case study of corn wet milling more closely than previous academic research on the commercial aircraft industry. Like Porter and Spence, we focus on a particular set of commitment opportunities and rely on a range of evidence to figure out what happened: pro forma models of the payoffs that the two companies attached, or should have attached, to various options, product market data and forecasts, capital market reactions to key events, and competitor action/response profiling. But there are also some differences that should be pointed out. We focus on a context where enormous economies of scale in relation to market demand have the effects of ensuring that there are only two competitors (versus a dozen in corn wet milling) and that discrete moves are clearly delineated (avoiding the need to artificially delineate a small number of strategic options), and where relatively fine-grained financial information at the level of individual competitors is available (the focus of section III). We also have more than 20 years of game-theoretic modeling in industrial organization to fall back on, and so manage to relate our empirical analysis to specific models of strategic product introduction (the focus of section IV).

III. Financial Modeling

To help assess the valuation impact of various strategic actions in this sequence of competitor interactions, we built financial models of Airbus' superjumbo development project and Boeing's 747 franchise. We begin our reviews of these models with a

projection of Airbus' investments in and returns from the superjumbo over a 20-year horizon (plus a terminal value). The model uses inputs from Airbus as well as from equity research reports on Airbus and EADS by analysts at Lehman Brothers (LB), CS First Boston (CSFB), Dresdner Kleinwort Benson (DKB), and The Airline Monitor (TAM), an industry consulting and data tracking service.

Before getting into more details about the expected financial returns from investing in the superjumbo, two limitations to our analysis are worth noting. First, this investment is incredibly complex and we have, by necessity, vastly simplified inputs to create a more tractable model. Specifically, we use discounted cash flow analysis, rather than real option analysis, to value the superjumbo. While one should recognize the optionality embedded in a launch decision, valuing these "real options" is exceedingly difficult given their complexity (i.e. multi-year, sequential construction expenditure, inability to observe the underlying asset, etc.) and the lack of publicly available data. Our focus on discounted cash flow analysis may matter less than it first appears to because of significant constraints on optionality in the launch of the superjumbo (see the discussion in Appendix 1). As a result, we believe we have captured the essence of this investment in a way that is approximately correct. The second caveat is that many of the inputs are informed estimates because Airbus has released few details other than expected investment costs. Critical details surrounding pricing, volume and, particularly, funding remain shrouded in secrecy. For example, *The Economist* noted, "The terms of the British government aid are suspiciously secret . . .(which) may indicate the rules have been stretched."[21]

With those caveats, we focus here on the key assumptions of the model and the principal results: additional discussion of key inputs and some omitted factors can be found in **Appendix 1**. The most critical assumption is that we treat the investment on a standalone basis financed with 100% equity. Whereas Airbus' investment is clearly equity, it is less clear how to treat the risk sharing capital and government launch aid. Arguably, these forms of capital more closely resemble cumulative preferred stock than debt because repayment occurs through a per plane fee: if Airbus does not sell any planes, it does not owe any money back.[22] With this assumption, it is appropriate to discount the cash flows at an un-levered cost of capital (the asset cost of capital,

10

described below). If one were to view the risk sharing capital or launch aid contributions as debt, then it would be necessary to account for the value derived from interest tax shields using either a levered cost of capital such as the weighted average cost of capital (WACC) or an alternative valuation method such as the adjusted present value (APV, see Myers, 1974). This assumption also means that our operating margins must be before repayment of capital contributions. A second important assumption is that we estimate project value as of year-end 2000, the date at which Airbus' supervisory board made the "go/no go" decision, and have ignored all expenditures prior to that date. By its own account, Airbus has spent $700 million on the plane by December 2000 (Airbus Briefing, 2000). Finally, we calculate the value accruing from years 1 to 20 (2001 to 2020) and use a terminal value to capture cash flows from years 21 to infinity.

The base case, which is reproduced in **Tables I** and **II**, can be read as a rough "what-if" analysis: how optimistic do we have to be about the volumes of and margins on superjumbos to make the project a value-enhancing proposition for Airbus? In the base case, we assume Airbus will sell 50 planes per year in steady state after an initial ramp-up period for a total of 701 planes by 2020. This number is slightly less than its stated goal of capturing half the projected market for superjumbos (1/2 * 1,550 planes = 775 planes). By way of comparison, the analysts are predicting that Airbus will sell from 515 planes (*The Airline Monitor*, Jan/Feb 2000, p.13) to 665 planes (LB, 1999, pp. 22-23) in their base case scenarios.[23] It is interesting to note that none of these estimates approaches the level in our base case, never mind Airbus' stated objective. More interestingly, Airbus' assumption exceeds the average number of 747's Boeing has sold over the past 30 years (35.2 planes per year).

We also assume the realized price in 2008 will be $225 million, which will produce an operating margin of 15%. This is a substantially higher margin level than reported by Airbus overall, or for that matter Boeing, although it does fall in between estimates in analysts' reports from Lehman Brothers (1999, p. 9) and DKB (2000, p. 30) that assume average margins of 14% and 19%, respectively on the superjumbo over the next 20 years. Some analyses do predict margins as high as 20-30% over time, on the grounds that margins tend to be higher on larger planes, but such predictions seem to assume away competitive pressures. They also seem high in relation to estimates that

Boeing, with more than 1,000 planes of cumulative production, has operating margins of 15% to 20% on its 747 jumbo, which monopolized its niche prior to the superjumbo.[24]

Place tables I and II approximately here

Using a discount rate of 11.0%, these inputs imply an NPV of $348 million.[25] Of this amount, investment outflows have an NPV of negative $5.69 billion, operating cash inflows through 2020 have an NPV of $4.23 billion, and the terminal value has an NPV of $1.81 billion assuming 2% growth. Note that without the terminal value for sales after 2020, the investment has a negative NPV of $1.46 billion. **Table I** also presents sensitivity analyses along several dimensions: operating margins, discount rate, tax rate, inflation rate, unit sales, investment expenditure, realized price, and sales ramp-up. Reducing the operating margin from 15% to 10% reduces the base case NPV by $2.0 billion, and to 5% by another $2.0 billion. Reducing the steady state number of planes sold from 50 to 30 reduces the NPV by $1.8 billion. Increasing the R&D investment cost from $9.7 billion to $11.7 billion reduces the NPV by $1.0 billion. Finally, delaying the initial sales by two years reduces the NPV by $1.0 billion.

This model can also be used to sharpen one's sense of how duopolists in the VLA market would fare. Assuming that both Airbus and Boeing spend the requisite $12 billion to develop a superjumbo, and that competition in the VLA segment drives margins down to 10%, each competitor would have a negative NPV unless they sold more than 70 planes per year. In other words, *each* competitor would have to sell 40% more planes than Airbus is predicting it can sell as a monopolist in the VLA segment just to break even! And if competition drove operating margins down to 5%, each would have to sell more than 140 planes per year—clearly an infeasible number. Sales of a more reasonable number of planes—30 to 50 per year—would result in massive losses for both firms, confirming the conclusions reached by the firms back in the early 1990s when they decided to collaborate. So financial modeling of the superjumbo suggests that while there *may* be room in the market for one new product of this sort, there certainly is not room for two entirely new products.

12

Given that at most one superjumbo was going to be launched, it is natural to ask why Airbus, not Boeing, decided to launch a superjumbo plane. In other words, why didn't Boeing preempt Airbus into the new segment? While the next section will develop a game-theoretic answer to this question, perhaps the most obvious alternate hypothesis about why Airbus, unlike Boeing, built the superjumbo is that it received a project-specific subsidy to do so whereas Boeing did not. Given that the estimated NPVs for the superjumbo range from the very negative to the slightly positive, the argument that the present value of the subsidy component of the launch aid of $2.5 billion was decisive in Airbus' decision to proceed cannot be dismissed outright. But if Airbus needed a subsidy to build the superjumbo, that does not mean that an unsubsidized project was not viable for Boeing. To be more explicit, *unsubsidized non-viability for Airbus does not imply unsubsidized non-viability for Boeing* because the value of exclusion to the incumbent is more than the value of entry to the entrant. The asymmetry arises from the anticipation that entry and subsequent price competition will reduce the incumbent's profits.

One can gain a sense of whether this theoretical effect is empirically significant through some more pro forma financial modeling, this time of Boeing's revenue and income streams from its jumbo airplane. Assume that Boeing sells 38 jumbos (747-400 planes) per year in each of the next 15 years. These assumptions are based on the fact that Boeing sold an average of 38 planes per year from 1995 to 1999, and that another 15 years of sales will give this version of the plane a life span that is slightly longer than the life span of the previous version, the 747-1/300. Now assume a realized price of $165 million per plane (rising at 2% per year for inflation); an operating margin of 20%; and a tax rate of 34%. Using a discount rate of 9.0% (Boeing's calculated WACC), the present value of the annuity stream is approximately $7.5 billion. This sum represents 12.7% of Boeing's total equity market capitalization at year-end 2000. Triangulating on the validity of this simple financial model, each 747 sold adds approximately 2.5 cents to Boeing's earnings per share, which is in line with what analysts assume in their reports.[26]

Now, if Airbus introduces a superjumbo, ending Boeing's monopoly position in the VLA segment, Boeing's profit margin on the 747 could fall from 20% to 10% or less, which is more typical for large airplanes facing direct competition.[27] According to our annuity model, this reduction in margin translates into a loss of $3.8 billion in present

value or a 6% drop in Boeing's total market value—the net value is $3.7 billion. Clearly, the anticipation of entry and subsequent price competition has large effects on the value of the 747 product—larger, specifically, than the present value of any subsidy inherent in the launch aid (which is likely to be only a fraction of $2.5 billion).

The specific magnitude of the gains to Boeing from preemption in such a context depends, of course, on assumptions about the margins that prevail if it manages to monopolize both the jumbo and superjumbo niches. Assuming (somewhat liberally) that Boeing achieves operating margins on its superjumbo at Airbus' targeted 15% level, that margins on its jumbo remain at 20%, and that volumes are unaffected at 50 superjumbos and 38 jumbos per year over the time periods specified above, then the present value of the operating profit stream to Boeing from monopolies in both the jumbo and superjumbo markets is $13.5 billion (= $7.5 billion from the jumbo and $6.0 billion from the superjumbo). The present value of the development and launch costs is $5.7 billion, which implies a net payoff of $7.8 billion from launching a superjumbo and monopolizing that niche. This sum substantially exceeds the $3.7 billion net payoff that Boeing can expect by conceding the superjumbo niche to Airbus and having to lower prices on the jumbo. And if superjumbo demand falls to the low level of 30 planes per year, then—under the assumption that that does not, by itself, affect jumbo prices— Boeing stands to make $5.4 billion from occupying and monopolizing the superjumbo niche versus $3.7 billion from conceding it to Airbus. Clearly, there is substantial room for Boeing to experience lower volumes than built into the base case—perhaps as a result of the high margins assumed—and yet still find it profitable to preempt Airbus. The more than $3 billion in market value at stake on the 747 drives a large wedge between the two competitors' payoffs from an investment in the superjumbo that effectively excludes the other. As a result, to say that subsidies were instrumental in Airbus' decision to build the superjumbo is not sufficient to explain why Boeing, which had quasi-rents to protect, did not build instead.

This financial model can also be used to form rough estimates of the additional value that Boeing might expect to derive from the 747 by delaying rather than deterring the launch of the superjumbo. Assuming that Boeing delays the superjumbo launch from 2006 to 2007, it receives one more year of monopoly profits in 2006 on the 747 (i.e. one

more year of a discounted future cash flow). Instead of earning no incremental profits after 2005, it receives no incremental profits after 2006 (there is full competition between the two firms). From Appendix 2, the loss is the present value of 2006 cash flows, which equals $509.9m from year 7 in the spreadsheet. So, the value to Boeing of a one-year delay in the launch of the A380 was approximately $500 million as of December 31, 1999.

Finally, we should conclude this discussion of the B747 jumbo and the A380 superjumbo by noting that by focusing on these two aircrafts, we ignore the impact of the latter's launch on other long-range wide-bodies, of which the A330 and the A340 are of the most interest from Airbus' perspective. This runs somewhat counter to the conclusions from the discrete choice random utility model estimated by Irwin and Pavcnik [2001] to infer the structure of the demand for differentiated airplane offerings: they conclude that the entry of the A380 will indeed toughen price competition and reduce the 747's market share, but that the cannibalization of the A330 and the A340 will be even greater (although Airbus' aggregate share, including the A380, will increase). Their results seem to be driven, however, by their assumption that cross-price elasticities are the same across all products within the long-range segment—an assumption that most analysts and industry executives would reject—and by their focus on the market share changes that ensue if incumbent products can adjust prices in response to entry: the price of the 747 falls significantly, so that its market share loss is limited, while the prices of the A330 and A340 optimally do not, so that they experience greater market share losses. But note that even if the A330 and the A340 do end up yielding more market share to the A380 than does the 747, it would be a mistake to conclude from that that the financial impact of cannibalization by the superjumbo is worse from Airbus' perspective (because of the effects on the A330 and the A340) than from Boeing's perspective (because of the B747). Remember that the 747 is both more profitable, prior to the launch of the superjumbo, than the A330 and A340, and closer in product space to the new product. Or to make the same point in a different way, even if the A380 does significantly cannibalize the A330 and the A340, that simply decreases the financial attractiveness of the superjumbo from Airbus' perspective; if Boeing continues to have a sufficiently larger amount of market value at stake on *its* key product, the 747, the puzzle as to why Boeing

didn't preempt persists. Game theory, or the explicit consideration of strategic interactions, seems to be the most compelling way to make sense of the lack of preemption.

IV. Models of Strategic Product Introduction

The broad game-theoretic insight that motivates our theoretical analysis is that the desire to protect a stream of quasi-rents (in Boeing's case, on its jumbo 747) may make preemption profitable, but is not sufficient, by itself, to ensure that preemption will occur. Preemption must also be credible. We make these points concrete by modeling competition in the VLA segment in terms of a standard Hotelling-type model of spatial competition in a market consisting of a line segment of unit length, with customer (airline) demand uniformly distributed along this interval. At one end of the interval, the incumbent already offers a product (the Boeing 747). The distribution of customer demand over the interval is best thought of in the VLA case as reflecting horizontal differentiation in preferred capacities based on differences in airlines' route structures.[28] The same basic set-up could also be used, of course, to analyze competition when customers are dispersed in geographic rather than product attribute space in ways that lead to significant transport costs.

Competition to supply new products to this continuum of customer demand is assumed to unfold in three stages. In the first or "innovation" stage, firms decide whether to invest in product innovation, in the second or "entry" stage, if they have invested in the first stage (and have been successful), they decide whether to enter the market with their new products and in the third or "pricing" stage, they decide prices for the products that they do end up offering. Similar results would be obtained if one collapsed the innovation and entry stages into product introduction as stage 1 and added in a product withdrawal/exit stage as stage 2, before getting to stage 3 pricing decisions. Either way, one has to work backward through the three stages, starting with equilibrium prices in stage 3 and the implications for expected operating profits as a way of getting, eventually, to long-run implications for market structure.

Let the net benefits of a customer located at x from buying a product located at s and priced at p be given by

$$u - p - t(s-x)^2. \tag{1}$$

Note, in particular, the assumption that "transportation costs," which can be thought of the cost of imperfect matches between product characteristics and customer preferences, are quadratic in distance.[29] If the net benefit in (1) is negative, then customers at this location do not buy the product; if the net benefit is greater than or equal to zero, then each such customer purchases one unit of the product or, in the event the market contains more than one product, one unit of the product that maximizes net benefits.

Initially, there is only one type of product offered in the market—think of this as Boeing's jumbo. It is located at 0 and produced by an incumbent firm, firm I. Assuming marginal costs of c, $u < c + 3t$ ensures that the market will be uncovered, i.e., some customers will fail to purchase the jumbo because it is too small for their needs. In such a situation, firm I's optimal price for its product will be given by $(2u+c)/3$.

We successively extend this one (product) location model to two product locations (with the second location corresponding to the superjumbo) and then to three (with the third location corresponding to the stretch jumbo). These two extensions help address our two key questions: why did Airbus, not Boeing, launch the superjumbo, and why did Boeing's "stretch jumbo" fail to deter Airbus from developing the superjumbo?

IV(i) Two Product Locations

Assume that a second product, the superjumbo (Airbus' A380), becomes available and is located at 1. If it is offered by a second firm, the potential entrant (firm E, or Airbus), and has equivalent marginal costs of c, then prices at the Bertrand-Nash equilibrium are given by min(u, c + t), and the market will be completely covered if $u > c + 1.25\,t$ (see Tirole [1988], chapter 7). The coverage condition seems to characterize the case being considered given the overlapping appeal of the jumbo and the superjumbo to some customers. For example, Singapore Airlines, one of Boeing's largest 747 customers, was

one of the early "launch" customers for the A380. Yet in the absence of larger offerings, Singapore probably would have purchased more 747s. In addition, without some overlap, there would be no demand-side interactions between the two products, and no difference between the incumbent and the entrant with regard to the incentives to launch new products. As a result, we assume that these two (or more) products cover the market.

Assuming that the market is covered, industry operating profits are no longer invariant to whether firm I or firm E introduces the new product at location 1.[30] If firm I introduces the new product, prices will be given by u - .25t which, if the inequality in the previous paragraph holds, is greater than c + t, the price level if firm E introduces the new product. This is the familiar result that monopoly is more efficient at generating profits than duopoly. An "efficiency effect" of this sort is what makes preemption by the incumbent profitable.

But even if preemption is profitable for the incumbent, it may not be feasible. Much of the game-theoretic literature on incumbent-entrant interactions in industrial organization (IO) consists of attempts to construct models of various exclusionary mechanisms that *can* make preemption effective: physical preemption, property rights, control of standards, privileged relationships/legal status, contractual commitments, exit costs, increasing returns to scale (including economies of scale, scope and learning), reputation for toughness, strategic information transmission/asymmetric information, et cetera (e.g., Tirole [1988]). In the context of strategic product innovation, the mechanisms that have been emphasized the most are patents/other intellectual property rights and the increasing returns to scale created by the fixed costs of new product development.[31] But in the context of very large aircraft, patent-based preemption does not seem to have been possible. And in the absence of such technology-based exclusion mechanisms, the preemptive incurral of development costs is of limited effectiveness in allowing the incumbent to lock the entrant out of the market. In other words, probably the most important insight from game-theoretic IO modeling in the present context is the negative one that large product development and introduction costs may well be an insufficient basis for successful preemption.

The relevant argument involves more careful consideration of competitors' strategy spaces and was originally developed in the context of a circular model of product differentiation by Judd (1985). In the present, linear context, reconsider the two firms' new product decisions and assume, for the sake of simplicity, that attempts at innovation always succeed.[32] If both firms somehow introduced a new product at location 1 by stage 3, prices at that location would fall to the common marginal cost of c, and no operating profits would be earned on the new product by either firm. This would also put pressure on firm I's price at location 0, which in equilibrium would fall to c + 0.5t, ensuring it total operating profits of t/8. In the absence of exit costs, firm I could improve its payoffs by withdrawing its product from location 1 and letting firm E monopolize it. In doing so, the incumbent could raise its price at location 0 to c + t (firm E's equilibrium price at location 1 would also now be c + t), earning operating profits of t/2. By implication, in the absence of exit costs, if both firms do end up entering at location 1, it is a dominant strategy for firm I to withdraw from location 1 and, since it is not credible for firm I to threaten to stay in the market, for firm E to stay. Anticipating this outcome, firm I rationally saves itself some money by refraining from innovate—even if it is certain that firm E will definitely enter if it does not. It is worth emphasizing that this prediction does not depend on the fixed costs of innovation/entry: exit costs are necessary to allow firm I to effectively "stake out" location 1 as the first-mover (Judd, 1985).

It is in this sense that game theory—or more specifically, the relatively subtle constraint that preemption be credible—helps rationalize why Airbus, not Boeing, introduced the superjumbo. Even if Boeing had threatened to build a superjumbo, Airbus could have called its bluff by proceeding with its own plans to launch one—at least under the hypothesis that both firms were value-maximizers, which we will scrutinize later. What it is time to turn to here is the second key question about their interactions: why Boeing also considered but failed in its attempts to proceed with a "stretch jumbo" intermediate to its jumbo and Airbus' planned superjumbo in terms of capacity. The analysis will, once again, focus on using expected operating profits at the end of stage 3 to help identify product configurations in the longer run.

Consider a model that allows for three product locations: the incumbent product at 0 (the jumbo), the entrant's product at 1 (the superjumbo), and a possible intermediate product (the stretch jumbo) introduced by the incumbent at location r [$\in(0,1)$]. The limit point r = 0 corresponds to the product market outcome if the incumbent decides not to introduce a new product at all (i.e., firm I offers a product at 0 and firm E offers a product at 1), while the limit point r = 1 corresponds to the outcome, already determined to be dominated by r = 0 from the incumbent's perspective, if the incumbent offers products at both 0 and 1 and the entrant offers a product at 1. Increases in r can be thought of as decreasing substitutability within firm I's product line while increasing it within firm E's product line.

Relatively general results for games with this structure indicate that increasing r has a positive direct effect on firm I's profitability, but that it is always countervailed by a negative *strategic* effect associated with the increasingly tough price competition with firm E that ensues as r increases (Cabral and Villas-Boas, 2001). Unfortunately, it is impossible to make general predictions about the relative size of the two effects.[33] But specific parameterizations, such as the model with quadratic costs and uniform distribution of demand developed in the last subsection, do indicate that it is possible for the negative strategic effect to dominate the positive direct effect for all positive choices of r. To rework that model in the present context, it is useful to begin by specifying the locations, dependent on prices, at which customers are indifferent between adjacent products.[34] Let x denote the indifference point between the product located at 0 and priced at p_0 and the intermediate product located at r and priced at p_r, and y the indifference point between that intermediate product and the product located at 1 and priced at p_1. See **Figure 2**.

Place Figure 2 approximately here

By definition,

$$p_0 + tx^2 = p_r + t(r-x)^2,$$

$$\Leftrightarrow \quad x = \frac{r}{2} + \frac{p_r - p_0}{2tr} \qquad (2)$$

and

$$p_r + t(y-r)^2 = p_1 + t(1-y)^2,$$

$$\Leftrightarrow \quad y = \frac{1+r}{2} + \frac{p_1 - p_r}{2t(1-r)} \qquad (3)$$

Firm I's operating profits, conditional on the choice of intermediate location r, are given by

$$\Pi_I = (p_0-c)x + (p_r-c)(y-x) \qquad (4)$$

$$= (p_0 - c)\left[\frac{r}{2} + \frac{p_r - p_0}{2tr}\right] + (p_r - c)\left[y - \frac{r}{2} - \frac{p_r - p_0}{2tr}\right]$$

Differentiating with respect to p_0, the first-order condition for an optimum is given by

$$p_0 = p_r + \frac{tr^2}{2} \qquad (5)$$

which implies in turn that

$$x = \frac{r}{4} \qquad (6)$$

Given equations (3)-(6), we can rewrite firm I's operating profits as

$$\Pi_I = \left(p_r - c\right)\left[\frac{1+r}{2} + \frac{p_1 - p_r}{2t(1-r)}\right] + \frac{tr^3}{8} \qquad (7)$$

Differentiating (7) with respect to p_r and setting the result equal to zero implies that

$$p_r = \frac{p_1 + c + t(1-r)(1+r)}{2} \qquad (8)$$

Similarly, one can differentiate firm E's operating profits,

$$\Pi_E = (p_1 - c)(1-y), \qquad (9)$$

with respect to p_1 and, setting the result to zero, obtain

$$p_1 = \frac{p_r + c + t(1-r)^2}{2} \qquad (10)$$

Given the first-order conditions for equilibrium in (8) and (10),

$$p_r = c + \frac{t(1-r)(3+r)}{3} \qquad (11)$$

and

$$p_1 = c + \frac{t(1-r)(3-r)}{3} \qquad (12)$$

Based on (11) and (12), the indifference points x and y and the two firms' operating profits could also be written out in closed form. But to gain an intuitive sense of the

implications, it is better to simply calculate price-cost margins, indifference points and profits across the domain of possible locations r $\in$ (0,1). The results appear in **Table III**.

Place Table III approximately here

Several patterns evident in **Table III** are worth stressing. First, normalized by t (a measure of the scope for product differentiation/heterogeneity that enters the firms' profit functions linearly), price-cost margins decline monotonically on all three products as r increases from 0 to 1.0. The price cost margin decreases from 1.0 to 0.5 in the case of the product located at 0, and from 1.0 to 0 for the other two products (particularly rapidly in the case of the entrant's product, located at 1). Second, because the entrant's market share declines, its normalized operating profit (Π_E/t) decreases as well: from 0.5 at the limit point of r = 0 to 0 at the limit point of r = 1. Third, while the incumbent's market share increases with r, this increase is insufficient to offset the lower price realizations as firm E reacts by cutting prices aggressively. As a result, Π_I/t is also inversely related to r: it decreases from 0.5 at the limit point of r = 0 to 0.125 at the limit point of r = 1 (in which case all the operating profit is generated by the product located at 0). In other words, the strategic effect dominates the direct effect for all values of r.

The last point implies, by analogy with the argument employed above in the two-product case, that the incumbent's launch of an intermediate product (the stretch jumbo) fails exactly the same credibility test for entry-deterrence as did its option of launching the truly new product, located at 1 (the superjumbo). The incumbent's equilibrium operating profits are higher without the intermediate product than with it. As a result, it will prefer to withdraw the product, even after it has been introduced unless, of course, there are significant exit costs.

This is a striking conclusion not because of the generality of this result—which has been established only in the context of a specific demand structure—but because it demonstrates by example the unreliability of a prediction that would probably command broad assent: that large efficiency advantages for the intermediate product over the truly new product (e.g., significantly lower development costs and/or quicker speed to market) make the former an effective vehicle for an incumbent to deter entry based on the latter if

the latter's economics are sufficiently marginal to start with. Boeing itself appears to have placed some emphasis on this advantage of the stretch jumbo over the superjumbo, at least in its public communications. According to one press report, "Boeing is banking on the fact that it should cost them far less to modify the company's existing 747-400 model than it will cost Airbus to build a completely new plane."[35]

What the theoretical model in this subsection suggests, by example, is that maybe Boeing should not have banked quite as much as it is asserted to have done on the efficiency advantages of the stretch jumbo. More broadly, purely efficiency-based predictions of which product will "win out" over the other are not always adequate. They need to be supplemented with some attention to strategic (in the sense of self-consciously interactive) considerations. These points are underlined by the evidence presented in the next three sections, which indicates that interactive considerations appeared to have significant influence on the outcomes observed so far in the VLA segment.

V. Product Market Data

The strategic models of product introduction in the previous section rationalize why Airbus, not Boeing, launched the superjumbo, and also why Boeing failed to proceed with the "stretch jumbo." But with a very limited number of key events, it is also easy to imagine non-strategic rationalizations additional to the ones already rejected (that the industry-profit maximizing outcome obtained, or that subsidies were decisive). To test for strategic effects against some of these alternate hypotheses, we start, as is customary in industrial organization, by looking at product market evidence about prices and quantities. But in other respects, the program is not very orthodox. The earlier use of pro forma financial valuations amounted to advocacy of the use of available measures of operating profitability even though costs are generally treated as unobservable in the fancier econometric work on industry analysis.[36] The sections that follow this one stress the utility of going beyond the traditional focus on product market evidence to also look at evidence from capital market reactions to news about development programs, particularly Boeing's and at evidence about its internal organizational arrangements— even though the evidence in the last category is mostly qualitative. And even in this

section, the approach adopted has been greatly affected by higher-level trade-offs between breadth and depth of coverage, which have generally been resolved in favor of the former. Overall, we have attempted to portray Boeing and Airbus' interactions in a way that is relatively complete, even if sketchy in some particulars, with the objective of assessing the cumulative weight of a body of evidence in a situation where it may not be possible to undertake one decisive test of the hypotheses on the table. To preview the conclusions, the weight of the evidence generally favors the hypothesis of intended but incredible—and therefore ultimately infeasible—preemption by Boeing.

V(i) Pricing Patterns

Pricing patterns in very large aircraft are of particular interest because pricing pressures drive the theoretical predictions that the entrant will introduce the new product (the superjumbo, in this case) and that intermediate products will be unprofitable for the incumbent. If one did not actually observe pricing pressures in the VLA segment as a result of Airbus' commitment to enter with a superjumbo and Boeing's efforts to enter with intermediate products, the credibility of the theoretical model would suffer in that case.

It is useful to begin this examination of pricing by noting several basic facts about it. First, both Boeing and Airbus post list prices for their entire product lines. Boeing, for example, shows a price range for each aircraft on its corporate web site, where the range depends on the specific configuration.[37] Second, both companies announce nominal changes to their price lists annually. In Boeing's case, the price changes are tied to an explicit formula that places a 65% weight on labor costs and a 35% weight on changes in the Producer Price Index (the PPI). Third, planes sell at large discounts to list prices, ranging from 18–40% for Boeing and 16-27% for Airbus according to recent data from *The Airline Monitor*.[38] Finally, although the manufacturers and their customers disclose realized prices only on an exceptional basis, industry analysts and trade journals such as *The Airline Monitor* ascertain reasonably accurate information by reverse engineering published financial statements and plane delivery records. Note that the

ability to reverse engineer-realized prices improves over time as more data become available.[39]

With that background, several indicators of pricing pressure in the very large aircraft segment can be cited. Starting with Airbus' A380 which has a list price of $218-$240 million in 2000. Given the 17-21% discount typical for the largest Airbus planes, the realized prices should be around $176 million assuming a list price of $220 million and a 20% discount. According to Airbus' CFO, it expects to make pre-tax margins of 20% over the next 20 years.[40] On a realized price of $176 million, this implies $35 million of operating profit on top of operating costs of approximately $140 million. As it turns out, however, the early sales have occurred at prices as low as $135-140 million or, in other words, essentially at "steady state" cost.[41] While some of the early launch customers like Qantas and Virgin reportedly paid approximately $150 million per plane,[42] Singapore Airlines reportedly paid only $140 million when it bought 10 aircraft in September 2000. Furthermore, Boeing was also reported to have cut the asking price on its intermediate product to $140 million in its unsuccessful attempt to win the Singapore Airlines order (off a list price of $185 million).[43]

One way of putting these prices in perspective is to note that they are on the low end even for the smaller 747, the production of which must be well down its learning curve. In a rare occurrence, Thai Airways disclosed in January 2001 that it paid $147 million for new 747-400s, a 20% discount off list price.[44] The magnitude of this discount, particularly for the limited number of planes on order, surprised industry analysts, prompting one to observe, "It's not the kind of number we have in our models. We are thinking that a 747-400 gets sold for more than that."[45]

In fact, since 1996, when Airbus' independent effort to develop a superjumbo started to take definite shape, data from *The Airline Monitor* indicate a real annual rate of decline of 2% through 2000 in Boeing's average realized price on the 747. This is a departure from previous pricing dynamics: between 1978 (year 10 of deliveries of the 747) and 1984, realized prices increased at an estimated real annual rate of 4%, and between 1984 and 1996 at 0.5% (helped by a model changeover to the 747-400, which started to be delivered in 1989).[46] By way of comparison, application of an 80% learning curve to 747 deliveries indicates that production costs have declined at a real annual rate

of 1-2%, perhaps exceeding the higher end of the range after the changeover to the 747-400 and verging on the lower end more recently.[47] So the period since 1996 stands out in the last 20 years of the 747's pricing history as being one of margin compression rather than margin expansion. Competition seems to have already put pressure on the prices of very large aircraft, although different explanations can be entertained as to "who started it."

An additional piece of evidence that points in the same direction involves comparing prices on VLA with the rest of Boeing and Airbus' product lines. **Figure 3** plots realized prices per seat (i.e., price divided by capacity) against product capacity, the product characteristic on which our earlier analysis focused. The data indicate a noticeable break in the positive correlation between prices per seat and capacity. This suggests, once again, significant pressure on prices in the VLA segment although to solidify this suggestion would require an analysis of cost per seat as well as price per seat versus capacity.

Place Figure 3 approximately here

Of course, Boeing's cancellation in early 2001 of the intermediate product does eliminate one source of pricing pressure. An analyst pointed out that one way to think about the positive reaction of both companies' stock prices to the cancellation—discussed further in the next section—was that Boeing was effectively announcing that it would abandon its cutthroat pricing policy and would price planes to make money, not to hold on to market share.[48] But cancellation of the intermediate product does not, by itself, reverse the downward trend that seems to have characterized 747 prices since 1996.

V(ii) Quantity Forecasts

The data available on VLA quantities are even more limited than the data on prices, for obvious reasons. The most relevant evidence seems to be that provided by Airbus' and Boeing's evolving 20-year forecasts for VLA deliveries. Because large aircraft take years to design and develop, require enormous up-front investment, and have useful lives

of over 30 years (some people think that the 747, for example, will have a useful life of 50-plus years), Airbus and Boeing both generate and publicly release long-term demand projections for their products. Airbus' *Global Market Forecast* (GMF) is based on annual demand for new aircraft on each of 10,000 passenger routes linking almost 2000 airports. Its model assumes that cargo and passenger demand will track GDP growth as it has for the past 50 years and estimates, for each airline, on each route pair, the need for specific aircraft, and compares that number with the existing stock of aircraft. In contrast, Boeing's *Current Market Outlook* (CMO) forecasts economic growth in 12 regions around the world and then uses these assumptions about growth to forecast traffic flows in 51 intra- and inter-regional markets.

As of 2000, Boeing and Airbus forecast relatively similar rates of growth in aggregate air traffic: 4.8% and 4.9% respectively. They disagreed sharply, however, about demand in the VLA segment. Specifically, while their forecasts of 20-year demand for VLA cargo jets were close (270 by Boeing versus 315 by Airbus), their forecasts of 20-year demand for VLA passenger jets were not (330 by Boeing versus 1235 by Airbus). This difference reflected differences in their perspectives on industry evolution—Boeing towards greater fragmentation and Airbus towards greater capacity planes.

Table IV summarizes Airbus and Boeing's evolving 20-year forecasts regarding the number of VLA passenger jet deliveries. As the comparison for 2000 suggested, Airbus' market forecasts have recently been several times as large as Boeing's. While both companies' forecasts fell in the late 1990s, primarily because of the Asian crisis, Boeing's fell much more.

Place Table IV approximately here

The Asian crisis is worth considering in a bit more detail because it accounts for an alternate hypothesis about what happened with VLA product introductions and retractions: essentially, that one-and-a-half new planes (the new superjumbo and the half-new stretch jumbo) were to be built but that in the aftermath of the Asian crisis, it became clear that only one new product could be accommodated by the market. The general

impact of the Asian crisis on demand for new aircraft cannot be overlooked since Boeing and Airbus continued, even after the crisis had bottomed out, to predict that the region would register the world's highest growth rates over the next 20 years.[49] But it is hard, specifically, to rationalize Boeing's announcements about the stretch jumbo—discussed in more detail in the next section—as having been driven by shifts in perceptions of the market due to the Asian crisis. Note that the stretch jumbo was cancelled for the first time before the Asian crisis first broke out in Thailand in spring 1997, and that in its second coming, from announcement to cancellation, lasted from September 1999 to March 2001. Boeing's second initiative with the stretch jumbo therefore started and ended after the region's economies were generally perceived to have bottomed out.

Returning to the magnitude of the divergence between Airbus' and Boeing's forecasts, it is made even more surprising by their collaborative efforts in the early and mid 1990s, a process that involved detailed discussion of different market forecasting techniques. That current forecasts nevertheless diverge so much is suggestive of the very large ambiguities inherent in coming up with long-run demand forecasts for products such as the VLA. Also interesting is the direction of the difference: Boeing's forecasts are lower than Airbus', not the other way around.

Although Boeing's lower forecasts may simply reflect its best estimates of future demand, a longer-term perspective raises questions about that interpretation. Consider Boeing's demand forecasts for large aircraft: the 747 plus the stretch/superjumbo plus large cargo aircraft. Between 1990 and 1994, Boeing's 20-year forecast for planes of this type nearly doubled from 1692 to 3,268. After stagnating in 1995, however, forecast demand tumbled by more than 70% through 1999, to just 933 planes in the latter year, or barely half the level the company had forecast in 1990, before the big run-up in the early part of the decade. The decline in Boeing's 20-year forecast between 1995 and 1996 alone amounted to more than 50%. As an Airbus executive put it, "It's difficult not to notice the discontinuity following the termination of the collaborative VLCT exercise and Airbus' announcement of the formation of a Large Aircraft Division to pursue the A3XX study."[50] Deliberate understatement of demand might have been intended to deter Airbus' entry. Or the intent might simply have been to delay entry, since delay could significantly increase the value of Boeing's 747 franchise, as calculated earlier. Sharp

cutbacks in Boeing's demand forecasts might, for instance, force Airbus back into market testing for another year. Similarly, the run-up in demand forecasts earlier on, when Boeing *was* collaborating with Airbus, can be rationalized as increasing the credibility of Boeing's push for a very large aircraft that would not compete with the 747 as opposed to a superjumbo-sized plane that would. Again, any delay would have been valuable. As a result, the possibility of strategic manipulation of forecasts merits mention, even though the statistical power with which it can be tested on its own (as opposed to in conjunction with other pieces of evidence of preemptive intent) is limited. We now proceed to look at some additional evidence.

VI. Capital Market Evidence

Capital market evidence receives much less attention in IO research than product market evidence, to an extent that is probably suboptimal. When levels of diversification are relatively low and key commitments hang in the balance, capital market reactions to announcements about them embody considerable information that is worth pressing into service. That is the tack taken in this section. It mostly focuses on news about Boeing and implications for Boeing's stock price because news about Airbus' intentions in VLA largely appears to have trickled out more gradually over time and because prior to their recent regrouping into EADS (plus British Aerospace), Airbus' operations were embedded in several much larger corporations.

VI(i) Reactions to the Stretch Jumbo

The key prediction from the three-location model is that if the incumbent (Boeing) does attempt to introduce an intermediate product to counter an entry threat (Airbus' superjumbo), announcement of that intent will decrease the incumbent's market valuation to the extent that it is "news," is taken seriously and is expected to lead to losses that are irreversible.[51] Conversely, retraction of the intent to pursue an investment strategy that does not maximize value should, under similar auxiliary conditions, increase the incumbent's market valuation.

It is worth pointing out that these predicted capital market reactions are the opposite of the positive reaction—a 2-day abnormal return of 5.6% (significant at the 5% level)—that Boeing experienced when it originally announced its 747 back in 1966 as well as larger sample evidence indicating positive capital market reactions, on average, to corporate announcements about new investments. For example, both McConnell and Muscarella (1985) and Chung, Wright, and Charoenwong (1998) find that firms experience significant, positive abnormal stock returns averaging 1.3% when they announce increases in capital expenditures. Similarly, Chan, Martin, and Kensinger (1990) find that firms experienced significant, positive abnormal returns averaging 1.4% when they announce new research and development (R&D) expenditures. Because development of a new aircraft involves both R&D and capital expenditures, these broader patterns are worth bearing in mind as we look at capital market reactions to Boeing's announced introductions and cancellations of its intermediate products.

Boeing did not formally announce that it was planning an intermediate product after its collaboration with Airbus on very large aircraft ended in July 1995; instead, news of Boeing's intentions appears to have trickled out over time. Nevertheless, it *is* possible to identify four discrete events since that time in which a plane intermediate to the jumbo and the superjumbo was prominently involved: see **Table V**.[52] All of the events are signed as predicted above: the capital market reaction was negative when Boeing announced that the intermediate product would cost more than expected, was positive when Boeing first canceled the intermediate product, was negative when Boeing restarted that program, and was positive when Boeing canceled it for the second time.[53] In addition, the reactions to the first two events are both statistically significant. Also note that for the first 3 events in Table IV, we cannot look at EADS'/Airbus' returns because EADS did not start trading publicly until July 2000. EADS' stock price reaction to the fourth event was positive but since this event was not limited to the stretch jumbo—Boeing also announced a new plane, the Sonic Cruiser—it will be discussed further in the next subsection.

Place Table V approximately here

31

Finally, it is also worth noting the capital market reactions to Airbus' announcement on December 19, 2000 that it was formally committing to launch the superjumbo—even though this announcement was partially expected since Airbus, on the strength of several large orders in the previous month, had crossed the threshold of 50 orders that it had said it needed to go ahead with the launch. Airbus experienced a positive 2-day return of 8.0% that was significant at the 5% level, while Boeing experienced a negative but insignificant return of –4.2%.

Taken together, these events and the reactions to them indicate that the capital markets considered the intermediate products investigated by Boeing likely to destroy shareholder value if pursued seriously. These findings are consistent with the strategic effect identified in the three-location model developed earlier.

V(ii) The Sonic Cruiser

The fourth event in **Table V** was a compound event: Boeing announced its "Sonic Cruiser" at the same time that it cancelled its stretch jumbo for the second time. This coupling has served as the basis for an entirely different hypothesis about competitive interactions in VLA. Gordon Bethune, who oversaw the development of the 737 and 757 planes at Boeing before becoming the CEO of Continental Airlines, described the sequence of moves as an explicit attempt by Boeing to "sandbag" Airbus:

> "They waited until the [A380] project gets launched and the other guys are committed to the project, and then they say: we're going fast, not big…[Airbus] can't catch up. They don't have enough resources since so much is committed to the big plane."[54]

Under this interpretation, far from being forced by credibility constraints to cede the superjumbo market, Boeing waited for and even encouraged Airbus to lock itself into an expensive development program. And once Airbus had committed to develop the superjumbo, Boeing announced a change in the game in large aircraft, from a focus on size to a focus on speed (and range), knowing that Airbus could not imitate.

To put the sandbagging hypothesis in perspective, note that if it were correct, the fourth event listed in **Table V** should have resulted in a *negative* return for Airbus' principal parent, EADS (European Aeronautic Defense and Space Company), as well as a *positive* return for Boeing.[55]   Interestingly, EADS experienced a *positive*, albeit insignificant 2-day abnormal return of 4.68% around that event (producing an abnormal change in market value of $640 million).[56] By taking a positive view of the net effects of Boeing's simultaneous cancellation of the intermediate product and announcement of a (possible) Sonic Cruiser on Airbus, investors apparently placed more emphasis on the benefit to Airbus of the cancellation and less on the threat from the Sonic Cruiser. This capital market reaction casts doubt on the "sandbagging" interpretation. So, too, do comments about the fourth event from industry analysts. According to one analyst, "This news is extremely important for Airbus and EADS as it significantly increases the probability that the A380 will be a commercial success."[57]

Of course, the Sonic Cruiser could pay off for Boeing without necessarily hurting Airbus. Addressing this possibility requires assessing the basic economics of the Sonic Cruiser which are still murky, not least because the development program is a year or two away from being initiated even if Boeing does decide to proceed with the plane.[58] Positive factors include time savings valued not only by passengers but also by airlines as enablers of more trips/plane and an extended range: 9,000 to 11,000 nautical miles versus 8,100 for the A380. On the other hand, there are significant issues with the Sonic Cruiser as well. Its total development and launch costs are projected to be $8 to $10 billion, smaller than the amount Airbus is budgeting for the A380, but still large enough to require a very large profit stream to be justifiable.[59] Furthermore, the Sonic Cruiser is perceived to require more new technologies than the A380 and, as a result of the implied "unknown unknowns," to be prone to proportionately larger overruns.   Other disadvantages include high operating costs associated with traveling at speeds just below the sound barrier and a probable need to focus on high-end passengers such as business travelers (which implies aggregation challenges). The Concorde, capable of flying twice as fast as the proposed new plane when it is allowed to break the sound barrier, exemplifies in extreme form how limiting these disadvantages can be. Also, if the Sonic Cruiser is launched, it will cannibalize demand for some of Boeing's most profitable

planes as well as Airbus'. Finally, the on-again off-again launch of the stretch jumbo probably complicates the launch of the Sonic Cruiser by reducing Boeing's credibility with the airlines for its level of commitment to launching previously announced new products.

For all these reasons, and the fact that Boeing has yet to commit to the Sonic Cruiser, it may plausibly (still) be regarded as a feint or a phantom plane that simply gave Boeing something positive to announce as it was forced, by credibility constraints, to withdraw from the contest to develop new very large aircraft. As we shall see in the next section, this was probably important for internal as well as external reasons.

VII. Organizational Evidence

The final category of evidence that we will look at in this paper is organizational in nature and is important to look at if one wants to understand not only why Boeing ultimately decided not to proceed with the stretch jumbo but also why it elected to announce the intermediate product in the first—and second—place. The negative capital market reaction to the initial announcement(s) suggests that investors, at least, attached a significant probability to the idea that Boeing might actually pursue a suboptimal, value-destroying path by introducing a stretch jumbo. Is such a mistake plausible in the context of the case being considered?

The game-theoretic literature on mistakes of this sort is sparse and generally seeks to rationalize excessive entry with intended profit maximization by invoking observational and entry lags (e.g., Cabral, 1997). But to address the possibility of deliberate non-maximization of corporate value, we must look internally, at Boeing's organizational structure and resource allocation process. While mostly qualitative analysis of this sort is more common in, say, political science or sociology than it is in industrial organization, prior case studies suggest that it can be enormously valuable in industrial organization as well.[60] In the present case, organizational analysis suggests that there was considerable impetus within Boeing to develop its own very large aircraft, increasing the perceived likelihood that the company might actually proceed with such a project even if it was expected to destroy shareholder value, and that some fundamental

macro-organizational changes were needed to tamp down that impetus.[61] By necessity, our reasoning in this regard can be reviewed in only highly abbreviated form.

There are a number of historical reasons why Boeing's commercial aircraft group might be expected, in the late 1990s, to have had some degree of discretion to influence the pursuit of strategies that emphasized investment and plane development instead of value maximization. For decades after it was founded in 1915, Boeing remained focused on military aircraft. But in 1952, it decided to wager a substantial fraction of its net worth on the introduction of the first commercial jet aircraft, the Boeing 707, at a time when Douglas, the leader in the commercial segment, and other producers continued to bet on propeller-driven planes. This "sporty" bet[62] made Boeing the leader in commercial aircraft, and it followed up with large-scale and ultimately successful commitments to the 727 and the 747 in the 1960s. As a result, risk-taking and "technical bravado" became deeply engrained values at Boeing, and were even feted publicly. According to James Collins, co-author of a best-selling book on visionary companies titled *Built to Last* (Collins and Porras [1994]):

> There's one thing that made Boeing really great all the way along. They always understood that they were an engineering-driven company, not a financially driven company. They were always thinking in terms of "What could we build?" not "What does it make sense to build?" If they're no longer honoring that as their central mission [with the concession of the very large aircraft segment to Airbus], then over time they'll just become another company."[63]

In the second half of the 1990s, the stretch jumbo program seemed essential to living up to this history: doing without it seemed to imply a break in the tradition at Boeing of always having a new plane on the drawing board. Rumors were reported to circulate at Boeing that it might shut down its group responsible for advanced designs.[64] And in 1999, Airbus outsold it for the first time in terms of unit orders. In the face of these events, considerable impetus apparently built up within the commercial aircraft group to use its sizeable and growing free cash flow—see **Figure 4**[65]—to proceed with a new

plane instead of ceding the VLA market to Airbus. And Boeing's senior management appeared to find the commercial aircraft group's claims on corporate wealth difficult to resist because the division still represented more than 60% of Boeing's total revenues and was a key part of company's corporate identity.

Place Figure 4 approximately here

That Boeing's top management ultimately *did* manage to resist the internal impetus to build a very large aircraft seems to reflect, in part, three macro-organizational changes at the company in the late 1990s. First, Boeing built up its defense, space and communications businesses by acquiring Rockwell International's aerospace businesses in 1996, McDonnell-Douglas in1997, and Hughes Space and Communications in 2000.[66] These acquisitions and a newfound emphasis on commercial aircraft services helped create growth options outside the traditional realm of commercial aircraft construction: in late 2001, Boeing executives have publicly stated that the company would stake near-term growth on its Southern California space, communications and missile operations instead of commercial aircraft.[67]

Second, aided by an inflow of top managers from McDonnell Douglas and elsewhere into what had historically been an insular, engineering-driven environment, Boeing instituted a much more detailed system of financial controls and performance measurement. A system for tracking product line profitability was reportedly put into place for the first time, and to further the company's stated goal of increasing its stock price five times in five years,[68] the Board instituted a new incentive program that linked compensation with stock price appreciation, and established stock ownership guidelines for top executives.[69] These changes facilitated a shift in the mode of resource allocation that placed more emphasis on efficiency and shareholder value rather than historical entitlement, engineering challenges, and a host of other non-economic criteria.

Third and most recently, Boeing decided to relocate its corporate headquarters from Seattle to Chicago. An important reason for the move, according to Boeing's top management, was the belief that the corporate center would remain too prone to the influence of the commercial aircraft group as long as the two headquarters remained

collocated in Seattle.[70] As CEO Philip Condit put it in an interview after the move, the previous headquarters in Seattle was "clearly related to commercial airplanes."[71]

To summarize, the organizational evidence presented in this subsection helps explain both why Boeing came close to developing the stretch jumbo and why it ultimately decided not to do so. The analysis also suggests a more internally-focused motive for Boeing's pre-announcement of the Sonic Cruiser—it may have needed a new program to engage its engineers following the cancellation of the stretch jumbo. This analysis supports the notion that traditional "no-fat" game-theoretic modeling of the interplay of incentives among competitors trying to maximize profits can often usefully be supplemented with detailed analysis of competitors' histories, strategies and organizational structures. For additional discussion of this point, see Ghemawat ([1997], chapter 8).

VIII. Conclusion

In addition to shedding light on a case that has attracted considerable public attention, this paper suggests that game theory can be useful to business strategy and that the case method can help connect the two. To begin with game theory, it provided a language and a set of logical tools for analyzing the competitive interactions in the market for very large aircraft. It also helped explain actual patterns of product introductions (and cancellations) in very large aircraft. And in addition to these analytical and descriptive purposes, it also offered the somewhat counterintuitive—and therefore presumably prescriptively valuable—insight that credibility constraints could lead to the more "efficient" of two candidate new products losing out.

Turning to the case method, its most obvious contribution in the present context was to help generate a relatively clean example of a stipulated theoretical effect—the importance of credibility constraints in spatial preemption—that has been discussed extensively, but in somewhat of an empirical vacuum. The process of relating the case to a theoretical framework also suggested a particular extension of standard spatial models of strategic product introduction, from two locations to three. And finally, the case method was used to test for the importance of the strategic effects highlighted by such

models in addition to exemplifying and adding to them. The tests relied on qualitative as well as quantitative evidence and drew heavily on financial and organizational as well as strategic analysis. They thereby underscored the importance of imagination in the choice of inferential methods given that many of the cases of interest from a strategic perspective often do not lend themselves to traditional large-sample analysis.

That said, this paper also suggests many additional avenues for research. One particularly interesting area is the organizational one. Were the macro-organizational changes at the corporate level some kind of endogenous response to organizational predispositions toward slack at the level of the commercial aircraft group (which would suggest that slack, like profits, tends to be characterized by a degree of mean-reversion)? Did Boeing's optimal (profit-maximizing) choice between value-maximization and sales-maximization depend on its beliefs about Airbus' choice between these roles—or should it have done? Could one, after making some assumptions that would enable the pro forma valuation of the stretch jumbo, disaggregate capital market reactions to it into their two components: changes in the assessed probability that Boeing would proceed with a value-destroying course of action and the consequences of its doing so? Can one study the motivations and behavior of the development engineers, who seem to have been a key internal constituency that Boeing had to try to co-opt, in more detail? And so on.

Another interesting area that has been treated only in highly simplified form in this paper is that involving interactions and relationships with customers. Can one relax the assumption of uniform posted (uniform) prices in the theoretical models developed in Section IV, to allow for customer-by-customer negotiation? The methods developed by Thisse and Vives (1988) can be applied fairly directly to demonstrating that the central insight from the two-location model, about the incredibility of self-cannibalization, continues to apply with customer-by-customer (albeit simultaneous) pricing instead of uniform posted prices, but the three-location extension would also be worth undertaking. Can the predictions that are tested account in a more satisfactory way for the durability of the product? Note that this is a problem that afflicts even studies that are otherwise very elaborate in their estimates of differentiated demand structures. And is it possible to measure, even roughly, the impairment to Boeing's reputation with airline customers as a result of its on-again off-gain efforts to launch the stretch jumbo? These and other

questions remain worth asking and answering. This paper set itself the more modest methodological task of illustrating the gains that can be had from looking beyond the usual data on prices and quantities to consider other kinds of evidence as well.

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Appendix 1

A Financial Model of the Airbus Superjumbo

Key Inputs to the Model

1) **Operating profit**: As of 2008, the price per plane is $225m, the number of planes in steady state production is 50, and the constant operating margin is 15%. We have ignored leaning curve effects. Incorporating learning effects and starting with a much lower initial margin lowers NPV unless one assumes that the operating margin exceeds 15% at some point in time.

2) **Sales ramp-up**: Based on assumptions in the models in the research reports.

	Plane Sales	
	20 years	10 years
Our Base Case	701	201
The Airline Monitor	515	125 (Jan/Feb, 2000, p. 13)
DKB analysis (pp. 27)		
High demand	644	175
Medium demand	553	130
Low demand	433	75
LB analysis (pp. 22-23)		
High demand	792	
Medium demand	665	184
Low demand	364	

If one uses a ramp-up schedule that matches what the analysts are predicting—a rate that is slower than our base case—the NPV falls to approximately zero.

3) **Launch costs**: According to Airbus, the total cost will be $10.7B for R&D and net working capital (NWC), and $1.2B for fixed assets related to final assembly (capital expenditures), for a total investment cost of $11.9B. The timing of expenditure follows the DKB research report.

4) **Funding sources**: Of the $11.9B total, $6.3B will come from Airbus, $2.5B from government launch aid, and $3.1B from Risk Sharing Partners.

44

5) **Discount rate**: The discount rate is the unlevered (asset) cost of capital, calculated according to the Capital Asset Pricing Model (CAPM, $K_A = R_f + \beta_A * R_P$) with the following inputs:

    a) risk-free rate = 6.0%, the yield on the 10-year US Treasury Note as of December 15, 2000.

    b) asset beta for commercial aviation = 0.84, the average asset beta derived from a market model using two years of daily data from 1/1/98 to 12/31/99 for Boeing and Bombardier.

    c) market risk premium = 6%, slightly below the arithmetic average of the difference between returns on large company stocks and returns on long-term government bonds of 7.3%according to Ibbotson and Sinqfield (2001), and the 7% average estimate from a survey of financial economists (Welch, 1999).

6) **Other inputs**:

    a) all analysis is done in US dollars; discounted to December 2000.

    b) inflation = 2%

    c) tax rate = 38%, the standard French rate even though EADS is a Dutch company. Analysts use rates ranging from 25 to 40%, and disagree on whether EADS/BAE Systems can use tax losses in the years incurred.

7) **Terminal value**: A growing perpetuity where growth is at the rate of inflation.

8) **On-going capital expenditures**: Equal to depreciation (10-year straight-line)

Omitted Factors:

1) **Capacity**: Investment will allow Airbus to produce up to 50 planes per year. We ignore additional expenditures needed to produce more than 50 planes per year or other versions of the jet (e.g. cargo version). Because most of the investment is needed for development ($10.7 billion out of $11.9 billion), investment to fund additional capacity expansion is likely to be relatively small in comparison.

2) **Cyclicality**: Although the industry exhibits considerable cyclicality, we have ignored this for the sake of simplicity. As shown in the sensitivity analysis in

Table I, a two-year delay in launch reduces the NPV by almost $1 billion while a slower than expected ramp up reduces the NPV by $0.3 billion.

3) **Pre-payments**: Airlines typically pay some fraction in advance or as construction occurs. We have ignored these payments and, instead, assume all costs and payments occur in the year of purchase. In essence, they involve just a shifting in the timing of cash flows. Shifting 25% of the revenue due forward by two years increases the NPV by $0.3 billion.

4) **Optionality**: Airbus' investment decision involves several possible sources of optionality (to ramp up, abandon, change, etc). For example, it took advantage of staged commitment by "testing the waters" to see if there was any demand for the product. Rather than proceeding with industrial launch as it did in December 2000, it could, in principle, have stopped the project and lost the $700 million incurred to that point. But it did receive what it considered to be positive information about demand for the plane and decided to proceed. Rather than valuing these "real options" as some have attempted (Shackleton, Tsekrekos, and Wojakowski, 2001), we utilize traditional discounted cash flow (DCF) analysis to estimate investment returns after calibrating our model to the models used by equity research analysts. Our focus on discounted cash flow analysis may matter less than it first appears to because of significant constraints on optionality in the launch of the superjumbo (see the discussion in **Appendix 1**). By Airbus' own admission, the majority of demand will not materialize until years 11 to 20, so there is only limited demand information available prior to spending the full development cost. Moreover, development and construction permits only limited staging because Airbus must spend almost the full $12 billion before it delivers the first plane. Finally, the highly specialized nature of the assets and development research implies that abandonment has little value.

5) **Boeing's response**: We have not explicitly modeled Boeing's response to Airbus' launch. Instead, we assume it can be captured through unit sales and margins.

Appendix 2
Valuation of Quasi-rents on the Boeing 747

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unit Sales (5 yr avg 95-99)		**38**	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Price		$165.0	$168.3	$171.7	$175.1	$178.6	$182.2	$185.8	$189.5	$193.3	$197.2	$201.1	$205.2	$209.3	$213.4	$217.7
Revenue		$6,270.0	$6,395.4	$6,523.3	$6,653.8	$6,786.8	$6,922.6	$7,061.0	$7,202.3	$7,346.3	$7,493.2	$7,643.1	$7,796.0	$7,951.9	$8,110.9	$8,273.1
Price inflation	2%															
Margins	**20.0%**															
Oper Margin		$1,254.0	$1,279.1	$1,304.7	$1,330.8	$1,357.4	$1,384.5	$1,412.2	$1,440.5	$1,469.3	$1,498.6	$1,528.6	$1,559.2	$1,590.4	$1,622.2	$1,654.6
Tax Rate	34%															
After-tax CF		$827.6	$844.2	$861.1	$878.3	$895.9	$913.8	$932.1	$950.7	$969.7	$989.1	$1,008.9	$1,029.1	$1,049.6	$1,070.6	$1,092.1
Discount rate	**9.0%** = Boeing's WACC for Commercial Airlines															
Discount Factor		0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422	0.388	0.356	0.326	0.299	0.275
Present Value		$759.3	$710.5	$664.9	$622.2	$582.3	$544.9	$509.9	$477.1	$446.5	$417.8	$391.0	$365.9	$342.4	$320.4	$299.8

NPV $7,454.8

		# of planes sold per year						
	$7,454.8	20	25	30	35	38	40	45
	5.0%	$981	$1,226	$1,471	$1,717	$1,864	$1,962	$2,207
Operating	10.0%	$1,962	$2,452	$2,943	$3,433	$3,727	$3,924	$4,414
Margin	15.0%	$2,943	$3,678	$4,414	$5,150	$5,591	$5,885	$6,621
	17.5%	$3,433	$4,291	$5,150	$6,008	$6,523	$6,866	$7,725
	20.0%	$3,924	$4,904	$5,885	$6,866	**$7,455**	$7,847	$8,828
	25.0%	$4,904	$6,131	$7,357	$8,583	$9,318	$9,809	$11,035

		Operating Margin			
	$7,454.8	10%	15%	20%	25%
	7.0%	$4,239	$6,359	$8,478	$10,598
	8.0%	$3,971	$5,956	$7,942	$9,927
	9.0%	$3,727	$5,591	**$7,455**	$9,318
WACC	10.0%	$3,506	$5,259	$7,012	$8,765
	11.0%	$3,305	$4,957	$6,609	$8,262
	12.0%	$3,121	$4,681	$6,241	$7,802
	13.0%	$2,952	$4,429	$5,905	$7,381

Figure 1

Commercial Jets: Range vs. Capacity
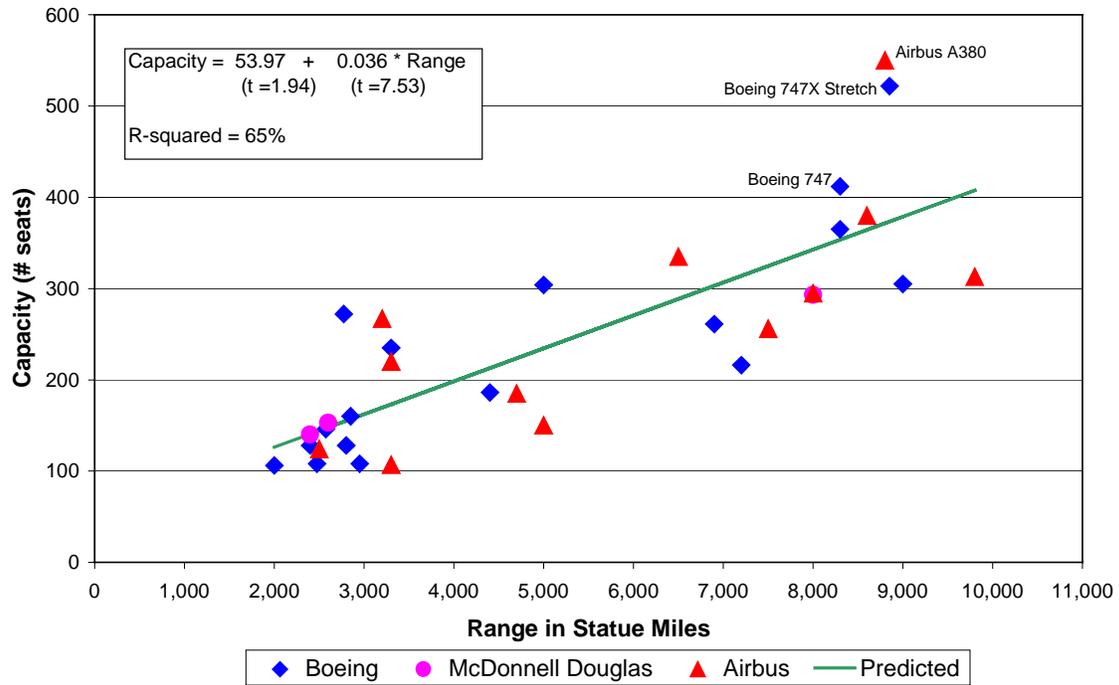
Source: Derived from data in *The Airline Monitor*, Jan/Feb 2001, pp. 18-19.

Table I

Simplified Valuation Analysis for the Airbus A3XX

Key Assumptions as of 2008

Price per Plane	$225	in millions
Number of Planes	50	in steady state
Operating Margin	15.0%	

Discount Rate Assumptions

Risk-free Rate	6.0%
Asset Beta	0.84
Risk Premium	6.0%
Discount Rate	11.0%

General Assumptions as of 2000

Inflation Rate	2.0%
Tax Rate	38.0%

Results from the Model

NPV =	$348	
After-tax IRR =	11.6%	
Pre-tax IRR =	14.7%	
# planes sold by 2010	201	in first 10 years
# planes sold by 2020	701	in first 20 years
Capacity Constraint Violated?	No	Max = 50/year

Required Investment as of 2000 ($millions)

Research & Development	$9,700
Capital Expenditures	$1,200
Net Working Capital	$1,000

Sensitivity Analysis

		Operating Margins				
	$348	5%	10%	15%	20%	25%
	8.0%	($2,774)	$824	$4,422	$8,020	$11,618
	9.0%	($3,222)	($303)	$2,617	$5,536	$8,456
Discount	10.0%	($3,511)	($1,091)	$1,328	$3,748	$6,167
Rate	11.0%	($3,702)	($1,677)	$348	$2,372	$4,397
	12.0%	($3,812)	($2,072)	($333)	$1,406	$3,145
	13.0%	($3,878)	($2,378)	($879)	$621	$2,121
	14.0%	($3,910)	($2,605)	($1,300)	$5	$1,310

		Operating Margins				
	$348	5%	10%	15%	20%	25%
	20	($4,918)	($4,110)	($3,301)	($2,493)	($1,684)
Steady	30	($4,511)	($3,294)	($2,078)	($862)	$354
State	40	($4,110)	($2,493)	($876)	$742	$2,359
# of	50	($3,702)	($1,677)	$348	$2,372	$4,397
Planes	60	($3,301)	($876)	$1,550	$3,976	$6,401
	70	($2,894)	($60)	$2,773	$5,607	$8,440

		R&D Cost				
	$348	$8,700	$9,700	$10,700	$11,700	$12,700
2008	165	($845)	($1,272)	($1,700)	($2,128)	($2,555)
Realized	185	($305)	($732)	($1,160)	($1,588)	($2,015)
Price	205	$235	($192)	($620)	($1,048)	($1,475)
Per	225	$775	$348	($80)	($508)	($935)
Plane	245	$1,315	$888	$460	$32	($395)

		Tax Rate				
	$348	15%	20%	25%	30%	38%
	0.0%	$671	$554	$436	$319	$132
	1.0%	$824	$695	$565	$436	$229
Inflation	2.0%	$1,011	$867	$722	$578	$348
Rate	3.0%	$1,244	$1,081	$919	$756	$496
	4.0%	$1,544	$1,357	$1,171	$985	$686
	5.0%	$1,943	$1,725	$1,507	$1,289	$940
	6.0%	$2,500	$2,238	$1,975	$1,713	$1,294

	Ramp-up (% of steady state sales)					
	2006	2007	2008	2009	2010	NPV
2 Year Delay	0%	0%	25%	75%	100%	($601)
Slow	10%	33%	67%	100%	100%	($90)
Expected	25%	75%	100%	100%	100%	$348
Fast	50%	100%	100%	100%	100%	$595

Table II

Simplified Valuation Analysis for the Airbus A3XX

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Required Investment										
Research & Development	$970	$1,940	$1,940	$1,940	$1,164	$776	$582	$388	$0	$0
Capital Expenditure	$0	$300	$420	$420	$60	$0	$0	$0	$0	$0
Net Working Capital	$0	$150	$300	$300	$200	$50	$0	$0	$0	$0
	$970	$2,390	$2,660	$2,660	$1,424	$826	$582	$388	$0	$0
Cumulative Start-up Investment										
Research and Dvlp	$970	$2,910	$4,850	$6,790	$7,954	$8,730	$9,312	$9,700	$9,700	$9,700
Capital Expenditures	$0	$300	$720	$1,140	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200
Net Working Capital	$0	$150	$450	$750	$950	$1,000	$1,000	$1,000	$1,000	$1,000
Cash Flows										
Revenue						$2,811	$8,382	$11,250	$11,475	$11,705
Ramp-up (% of steady state sales)						25%	75%	100%	100%	100%
Number of Planes						13	38	50	50	50
Price per Plane						$216	$221	$225	$230	$234
Operating Profit						$422	$1,257	$1,688	$1,721	$1,756
Development Costs										
R&D Expense	($970)	($1,940)	($1,940)	($1,940)	($1,164)	($776)	($582)	($388)	$0	$0
Depreciation	$0	($30)	($72)	($114)	($120)	($120)	($120)	($120)	($120)	($120)
Depr. Adjustment	$0	$0	$0	$0	$0	120	120	120	120	120
EBIT	($970)	($1,970)	($2,012)	($2,054)	($1,284)	($354)	$675	$1,300	$1,721	$1,756
Taxes @ 38%	$369	$749	$765	$781	$488	$135	($257)	($494)	($654)	($667)
EBIAT	($601)	($1,221)	($1,247)	($1,273)	($796)	($220)	$419	$806	$1,067	$1,089
+ Depreciation	$0	$30	$72	$114	$120	$120	$120	$120	$120	$120
- Capital Expenditures	$0	($300)	($420)	($420)	($60)	($120)	($120)	($120)	($120)	($120)
- Incr. in Working Capital	$0	($150)	($300)	($300)	($200)	($50)	($20)	($20)	($21)	($21)
Free Cash Flow	($601)	($1,641)	($1,895)	($1,879)	($936)	($270)	$399	$785	$1,046	$1,067
Discount Rate 11.0%										
Discount Factor	0.901	0.811	0.730	0.658	0.592	0.533	0.480	0.433	0.390	0.351
Terminal Value (Growing Perpetuity)										
Growth rate 2.0%										
Total Free Cash Flow	($601)	($1,641)	($1,895)	($1,879)	($936)	($270)	$399	$785	$1,046	$1,067
Discounted FCF	($542)	($1,331)	($1,384)	($1,236)	($555)	($144)	$192	$340	$408	$375
Present Values										
Investing CF to 2020	($5,691)									
Operating CF to 2020	$4,231									
Terminal Value after 2020	$1,808									
Net Present Value	$348									
Internal Rate of Return (after tax)	11.6%									

50

Table II (continued)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Required Investment											
Research & Development	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Capital Expenditure	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Working Capital	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cumulative Start-up Investment											
Research and Dvlp	$9,700	$9,700	$9,700	$9,700	$9,700	$9,700	$9,700	$9,700	$9,700	$9,700	$9,700
Capital Expenditures	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200
Net Working Capital	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Cash Flows											
Revenue	$11,939	$12,177	$12,421	$12,669	$12,923	$13,181	$13,445	$13,714	$13,988	$14,268	$14,553
Ramp-up (% of steady s	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Number of Planes	50	50	50	50	50	50	50	50	50	50	50
Price per Plane	$239	$244	$248	$253	$258	$264	$269	$274	$280	$285	$291
Operating Profit	$1,791	$1,827	$1,863	$1,900	$1,938	$1,977	$2,017	$2,057	$2,098	$2,140	$2,183
Development Costs											
R&D Expense	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Depreciation	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)
Depr. Adjustment	$120	$120	$120	$120	$120	$120	$120	$120	$120	$120	$120
EBIT	$1,791	$1,827	$1,863	$1,900	$1,938	$1,977	$2,017	$2,057	$2,098	$2,140	$2,183
Taxes @ 38%	($680)	($694)	($708)	($722)	($737)	($751)	($766)	($782)	($797)	($813)	($830)
EBIAT	$1,110	$1,132	$1,155	$1,178	$1,202	$1,226	$1,250	$1,275	$1,301	$1,327	$1,353
+ Depreciation	$120	$120	$120	$120	$120	$120	$120	$120	$120	$120	$120
- Capital Expenditures	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)	($120)
- Incr. in Working Capital	($22)	($22)	($23)	($23)	($23)	($24)	($24)	($25)	($25)	($26)	($26)
Free Cash Flow	$1,089	$1,110	$1,133	$1,155	$1,178	$1,202	$1,226	$1,251	$1,276	$1,301	$1,327
Discount Rate 11.0%											
Discount Factor	0.316	0.285	0.256	0.231	0.208	0.187	0.169	0.152	0.137	0.123	0.111
Terminal Value (Growing Perpetuity)										$14,680	
Growth rate 2.0%											
Total Free Cash Flow	$1,089	$1,110	$1,133	$1,155	$1,178	$1,202	$1,226	$1,251	$1,276	$15,981	
Discounted FCF	$344	$316	$290	$267	$245	$225	$207	$190	$174	$1,968	

Figure 2
Products, Prices, and Customer Indifference Points with Three Locations

Product 0   x   Intermediate   y   Product 1
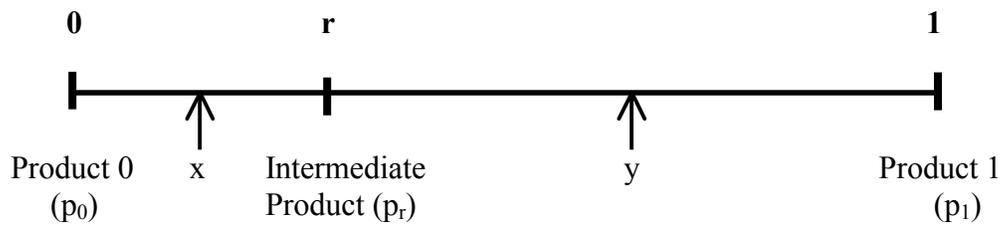
(p_0) Product (p_r) (p_1)

Table III
Equilibrium in the Three Location Model

	Normalized Price-Cost Margins: $(p_i - c)/t$			Breakeven Points		Normalized Profits Π_i/t	
r	Incumbent's Original Product at 0	Incumb.'s Intermed. Product at r	Entrant's New Product at 1	X	Y	For the Incumbent	For the Entrant
0.0	1.000	1.000	1.000	0.000	0.500	0.500	0.500
0.1	0.965	0.960	0.885	0.025	0.517	0.496	0.428
0.2	0.927	0.907	0.773	0.050	0.533	0.485	0.361
0.3	0.885	0.840	0.665	0.075	0.550	0.465	0.299
0.4	0.840	0.760	0.560	0.100	0.567	0.439	0.243
0.5	0.792	0.667	0.458	0.125	0.583	0.405	0.191
0.6	0.740	0.560	0.360	0.150	0.600	0.363	0.144
0.7	0.685	0.440	0.265	0.175	0.617	0.314	0.102
0.8	0.627	0.307	0.173	0.200	0.633	0.258	0.064
0.9	0.565	0.160	0.085	0.225	0.650	0.195	0.030
1.0	0.500	0.000	0.000	0.250	0.667	0.125	0.000

Table IV
20-Year Forecasts of the Number of VLA Deliveries
(Passenger Jets > 500 seats only)

	Boeing CMO Forecast	Airbus GMF Forecast
1995	n/a	1374
1996	n/a	n/a
1997	460	1442
1998	405	1332
1999	365	1208
2000	330	1235
2001	340	1256

Source: Boeing Current Market Outlook (CMO) and Airbus
Global Market Forecast (GMF), various years.

Table V
Capital Market Reactions to Boeing's Announcements about Intermediate Products

Event	Date (Day 0)	2-Day (-1, 0) Abnormal Return (p value) [a]	2-Day Abnormal Change in Market Value ($ millions)
1) Revised 747 models to cost $7B not $5B	11/1/96	(3.01%) [b] 10.4%	($989)
2) Boeing cancels revised 747 models	1/21/97	6.46% 0.1%	$2,393
3) Boeing to proceed with 747X-Stretch	9/20/99	(3.07%) 37.8%	($1,296)
4) Boeing cancels 747X Stretch; to proceed with the Sonic Cruiser	3/29/01	2.43% 45.3%	$1,172

Notes:
[a] Abnormal returns are calculated using a standard market model (see MacKinley, 1997) with the S&P 500 as the market return and a 200 day estimation window running from day –220 to day -21. Negative returns appear in parentheses.
[b] Although the two-day return is marginally significant at the 10.4% level, the one-day abnormal return is significant at the 1% level.
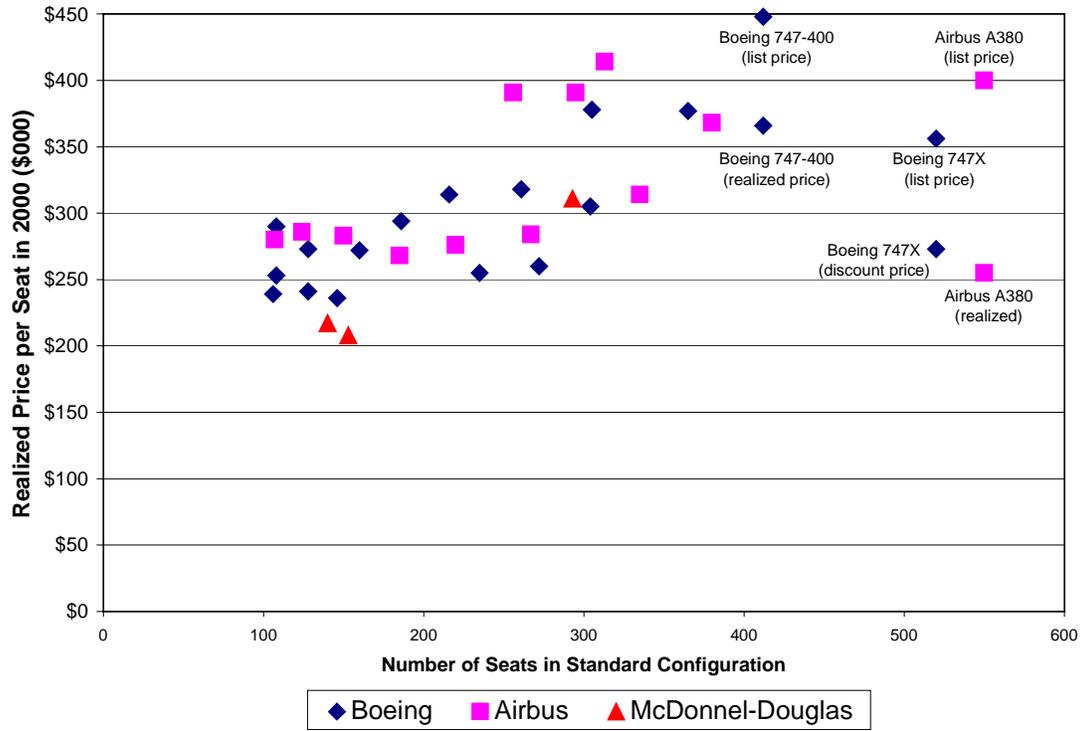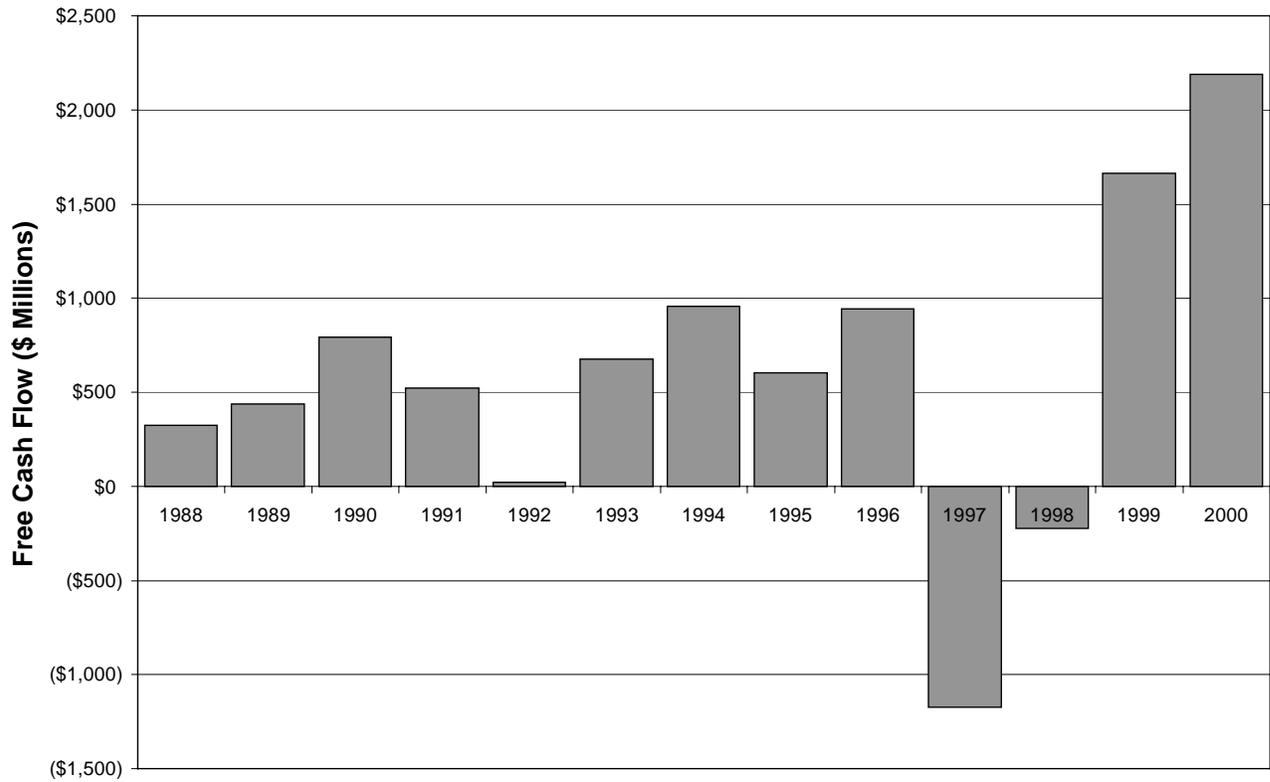
Figure 3
Realized Price per Seat

Figure 4
The Boeing Company's Free Cash Flow [*]

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[*] Free Cash Flow = EBIT (1-tax) + Depreciation – Capital Expenditures – Increases in Net Working Capital
(Source is Boeing Annual Reports, various years). Because Boeing does not report working
capital on a divisional level, the calculation ignores changes in new working capital.

Endnotes

[1] Data based on Boeing's 2000 Current Market Outlook. See also *The Airline Monitor*, July 2000.

[2] Airbus' Global Market Forecast (GMF) defines the VLA market as consisting of passenger aircraft with more than 500 seats and cargo aircraft capable of handling more than 80 tones of freight. In contrast, Boeing's Current Market Outlook (CMO) defines the VLA market as aircraft seating more than 400 passengers, the size of the 747.

[3] Most of the background material contained in Sections II and III comes from Esty and Kane's (2001) teaching case on the Airbus A3XX, later renamed the A380. In an attempt to verify the teaching case's representation of facts, we sent copies to and received comments from senior executives at Boeing and Airbus as well as equity research analysts at investment banks who follow both companies and industry consultants. While their comments corrected some factual errors and highlighted alternative interpretations, they do not constitute approval of the case or its content.

[4] According to *The Airline Monitor,* Jan/Feb 2001 and *CSFB Global Commercial Aerospace Monthly*, May 2000.

[5] Cole, J., 'Airbus Prepares to 'Bet the Company' as It Builds a Huge New Jet', *The Wall Street Journal*, 11/3/99, p. A1.

[6] Cole, J. and B. Coleman, 'Airbus Denies it Has Been Cut From Jet Talks', *The Wall Street Journal*, 1/7/93, p. A4; Coleman, B., 'Accord With Airbus to Study Superjumbo a Win for Boeing', *The Wall Street Journal Europe*, 1/28/93, p. 3.

[7] Cole, J., 'Boeing, Two Airbus Members In Talks to Develop New Jet', *The Wall Street Journal Europe*, 1/5/93, p. 3.

[8] Coleman, B., 'Accord With Airbus to Study Superjumbo a Win for Boeing", *The Wall Street Journal Europe*, 1/28/93, p. 3.

[9] 'Airbus, Boeing Reportedly scrap Plans for Super Jumbo Venture, *AFX News,* 5/15/95.

[10] 'Boeing Delays May Force Review of Venture', Nihon Keizai Shimbun, 4/8/89, p. A3; 'Dropping Japan for China', *The Economist*, September 9, 1995, p. 66.

[11] Cole, J., 'Boeing-led Allince Halts Superjumbo Jet', *The Wall Street Journal*, 7/10/95, p. A3.

[12] Sell, T.M., 'Boeing May Soon Launch Updated 747s', *Seattle Post Intelligencer*, 5/28/96, p. B1.

[13] Cole, J., F. Rose, and C. Goldsmith, 'Boeing's 747 Decision Shifts Rivalry With Airbus', *The Wall Street Journal*, 1/22/97, p. A3.

[14] Airbus A3XX Briefing to Financial Analysts, 10/4/00.

[15] *The Airline Monitor*, Editor Edmund Greenslet, comment during a personal interview on 9/28/00 with Mike Kane.

[16] Prada, P., 'Airbus Industrie Board Gives Superjumbos Final Approval, *The Wall Street Journal*, 12/20/2000,online edition.

[17] European Aeronautic Defence and Space Company, N.V., Reference Document 2000, pp. 39-40.

[18] Rothman, A., 'Airbus Chief Justifies Customer Discounts', *The Seattle Times*, 3/24/01, p. E1.

[19] "Airbus A380: The World's Largest Commercial Jet," Presentation at the Harvard Business School by Adam Brown, January 30, 2002.

[20] 'Emirates Announces $15bn Aircraft Order', *Financial Times*, 11/5/01, p. 17.

[21] 'Airbus bets the Company', *The Economist*, 3/18/00, p. 67.

[22] Estimates of the per plane fee range from $11 to $18 million from DKB (2000, p. 25) to $7.5 million from LB (1999, p. 24).

[23] Our model assumes that Airbus will sell 201 planes in the first 10 years. According to the analysts, Airbus will sell 130 (DKB, 2000, p. 27) to 184 (LB, 1999, pp. 22-23) planes in the first 10 years in the base case scenarios. Thus, we are assuming a faster ramp-up in sales though we analyze the sensitivity to this assumption in **Table I**.

[24] Lehman Brothers (12/6/99, p. 16) assumes Boeing earns an operating margin of 15% on large aircraft. DKB assumes the operating margin is 15-20% (5/8/00, p. 6). Most analysts believe that both Airbus and Boeing make virtually all of their profits on their widebody jets.

[25] By way of comparison, Lehman Brothers (12/6/99, p. 20) uses a WACC of 13.4% in its analysis, which implies an even higher asset cost of capital. In more recent analysis, CSFB (3/14/01, p. 236) uses a WACC of 9.1% for EADS.

[26] Holmes, S., 'Boeing turnaround shows up in results', *The Seattle Times*, 10/15/99, p. E1. Robinson, P., 'Boeing orders could Boost Earnings', *Seattle Post-Intelligencer*, 8/5/99, p. C1.

[27] In recent years, Airbus has earned operating margins of 3.9% to 8.5% and is projected to earn margins of 4.9% to 8.5% through 2005, according to CS First Boston (reports on EADS, 3/14/01). Boeing, on the other hand, earns an operating margin of 8-10% in a typical year in its commercial airplane division (Boeing Annual Reports). Boeing's higher margin is, in part, due to the high margins on its jumbo.

[28] While product comparisons in this industry often focus on two distinct major characteristics—capacity and range—the two tend are highly collinear. As seen in **Figure 1**, capacity and range are significantly, positively related. Also, range is arguably becoming less of a factor as the proposed large aircraft come closer to being able to fly half-way around the world nonstop.

[29] Linear transportation costs tend to yield similar results, but are more prone to discontinuities in payoff functions and the consequent problems with the existence of equilibria in pure pricing strategies.

[30] Note that coverage of the market with interfirm competition is necessary but not sufficient to guarantee coverage without interfirm competition. While this is a source of additional complexity, it does not affect the basic logic of the argument developed in this subsection.

[31] Consult, for instance, Gilbert and Newbery (1982) and (1984); and Reinganum (1983) and (1985).

[32] Ghemawat (1991) analyzes similar issues in the context of product innovation in PBXs with a model in which innovation is permitted to be stochastic but the demand structure is more constraining.

[33] Such predictions are possible for symmetric cases, subject to several auxiliary qualifications elaborated by Cabral and Villas-Boas (2001). Thus, extend the model

considered in the previous subsection to let both firm I and firm E introduce (symmetrically situated) intermediate products. Then, known results would guarantee that the negative strategic effects outweighed the positive direct effects in this four-product case. The discussion in this subsection focuses, however, on the asymmetric case of three products.

[34] Although similar results have been reported by Martinez-Giralt and Neven (1988) and Bonnano (1987), neither completely characterizes the equilibrium pricing strategies in the stage 3 subgame.

[35] Mike Maharry, 'Boeing Says It Has Been Offering New 747 Versions for Months', *The News Tribune* (Tacoma, Washington), June 24, 2000, p. D1.

[36] Caves (1994, p. 14) suggests that this is one of the respects in which case study research can supplement more standard statistical studies of competitive processes in individual markets.

[37] The prices appear on the Boeing web site at http://www.boeing.com/commercial/prices/index.html.

[38] *The Airline Monitor,* (Jan/Feb 2001, Table 6).

[39] In the case of The Airline Monitor, it compares unit sales and estimated realized prices against published financial statements. Over time, it has refined its pricing model to the point where it has a high degree of confidence in its ability to estimate average realized prices.

[40] Matlack, C., S. Holmes, and C. Dawson, 'Giving 'Em Away?' Business Week, 3/5/01, p. 52.

[41] Matlack, C., S. Holmes, and C. Dawson, 'Giving 'Em Away?' Business Week, 3/5/01, p. 52; Lehman Brothers 10/2/00, p. 3.

[42] M. Flores, 'Airbus Set to Launch its Monster Jet,' *The Seattle Times*, 12/19/00, p. D1.

[43] The Lehman Brothers Equity Research Report, 10/2/00, p. 3, suggests a price of $135-$140 million; 'Boeing Loses Singapore Airlines Jet Order to European Rival Airbus Industrie', *The Seattle Times,* 9/30/00, suggests $142 million.

[44] Wallace, J., 'Thais get a good deal on Boeing 747; competition with Airbus spurs cuts,' *Seattle Post-Intelligencer*, 1/12/01, p. D1.

[45] Wallace, J., 'Thais get a good deal on Boeing 747; competition with Airbus spurs cuts, *Seattle Post-Intelligencer*, 1/12/01, p. D1.

[46] Sutton, Oliver, 'What's in a price hike?" *Interavia Business & Technology*, 12/1/98, pp. 36-38.

[47] The use of an 80% learning curve is common to and apparently even originated in the airframe sector of the aircraft industry. See Hartley [1968].

[48] Reuters, as quoted from Yahoo!Finance News, "Boeing to shelve superjumbo', 3/28/01.

[49] 'The Size Equation', *Airline Business,* April 1999, p. 52.

[50] E-mail from Adam Brown, Airbus' Vice President of Market Forecasts, to Ben Esty, February 7, 2002.

[51] Note that the presumptions underlying such an inference are staples of "event-study" methodology, which is commonly used in finance (MacKinlay, 1997).

[52] There are also many seemingly less important, predicted, and even contaminated events that generate insignificant returns. For example, Boeing's most recent twist as of this writing—the announcement in mid-April that it would develop a longer-range alternative to the 747 with a handful of extra seats—elicited an insignificant -0.09% return over the standard two-day "event horizon".

[53] The second cancellation was coupled with the announcement of a new 'Sonic Cruiser', contaminating the capital market reaction observed. How to make additional headway is discussed in the next subsection, in the broader context of the Sonic Cruiser.

[54] Matthew Brelis, 'Faster vs. Bigger', *The Boston Globe*, May 6, 2001, p. C7

[55] The impact of the earlier events in **Table V** on Airbus/EADS cannot be examined analogously because Airbus was an untraded consortium of European aerospace companies whose revenues and market values were dominated by their other businesses. EADS grouped together the Airbus-related interests of three of the original parents into a 80% stake in Airbus Integrated Company; the fourth, British Aerospace, separately held the remaining 20%.

[56] Based off data from the Paris stock exchange using the CAC40 as the market index and a 160-day estimation window. Because of time differences, event day 0 is 3/30/01. The

number of shares outstanding is 807.2 million as of March 2001. Note the results change slightly depending on the stock exchange (Paris, Madrid, or Frankfurt) and the length of the estimation window (80 to 160 days).

[57] 'EADS Takes Off as Boeing Scraps Superjumbo Plans', *Reuters News,* 3/30/01.

[58] Joseph Campbell, an aerospace analyst at Lehman Brothers, commented, "We wouldn't think that the new Sonic Cruiser would enter service earlier than 2008 timeframe. We wouldn't normally expect quite this much planned publicity on a plane whose launch is certainly 3-4 years into the future, and whose entry into service is 8 to 10 years out." (Lehman Brothers, Equity Research report, 3/30/01, p. 2.)

[59] Morgan Stanley Dean Witter Equity Research Report, 'Boeing Company', March 20, 2001, p. 2.

[60] Consult, for instance, the abbreviated "competitor analyses" in Porter and Spence's [1982] case study of corn wet milling.

[61] It is also worth discussing another kind of macro-organizational change--the corporate spin-off of a division or subdivision charged with innovation--that might, in theory, resolve such incentive problems (Baldwin, 1983). In the present case, the creation of incentives to develop a VLA (assuming that it could be expected to be profitable in standalone terms, without accounting for losses from cannibalizing the 747) would have required hiving off the VLA project from the rest of the commercial aircraft group, which would appear to have been infeasible for both technical and marketing-related reasons. And even if such a spin-off *had* been feasible, effecting it after the competitive threat from Airbus had materialized would have led to a net destruction of shareholder value since the value of the portion of the company being spun-off would have been more than offset by the value impairment suffered by the rest of the company.

[62] John Newhouse coined this term in his book, *The Sporty Game* (1982), to refer to the high-risk nature of commercial plane development. He writes (p. 3), "But what really sets the commercial airplane business apart is the enormity of the risks as well as the costs that must be accepted; they create an array of obstacles to profitability, hence viability, which discourages all but the bold and committed."

[63] Jerry Useem, 'Boeing vs. Boeing', *Fortune*, 10/2/00, pp. 148-160.

[64] Jenkins, H.W., Jr., 'Haven't shareholders had enough chicken', *The Wall Street Journal*, 4/4/01, p. A21.

[65] Free cash flow for the commercial airplanes division is defined as earnings from operations less taxes at 34% (EBIAT), plus depreciation, minus capital expenditures. In its annual reports, Boeing breaks out these accounting entries on a division level, but does not allocate working capital by division. Thus, the calculation does <u>not</u> include changes in net working capital. Also note that the downturns in 1997 and 1998 reflected production problems following the acquisition and integration of McDonnell Douglas's operations.

[66] Although the McDonnell Douglas acquisition did bring in some commercial aircraft business, it, like the other acquisitions, was focused on other businesses.

[67] Bridges, A., 'California Boeing to Focus on Space and Communications, Not Aircraft,' *Los Angeles Times*, 10/12/2001, p. C-2.

[68] Stepankowsky, P.A., 'Boeing CFO: Co. Focused on Plane Delivery, New Initiatives', Dow Jones News Service, 3/23/00.

[69] The Boeing Company, Proxy Statement, 3/11/00, pp. 29-30.

[70] Jenkins, H.W., Jr., 'Haven't shareholders had enough chicken', *The Wall Street Journal*, 4/4/01, p. A21. Also, Schafer, S., 'Boeing Picks Chicago for Headquarters; Firm Wanted Base Centrally Placed, Away From Units', *The Washington Post*, 5/11/01, p. E3.

[71] 'Interview: Phil Condit', *Financial Times*, 1/3/02, p. 22.