CHAPTER 2

AIRCRAFT

> [The airline business]… has historically run as an extremely elaborate version of a model railroad, that is one in which you try to make enough money to buy more equipment.[33]

An economic recession, high oil prices, and an air traffic controllers' strike made the airlines' transition into deregulation in the early 1980s a bumpy ride. Aggressive competition over high-density linear routes resulted in industrywide losses. With an oversupply of equipment, airlines resorted to grounding mostly older-generation aircraft, and labor forces were severely pared down. Yet, as is often the case in a highly cyclical industry, boom follows gloom, and an impressive economic recovery accelerated demand for air travel during most of the 1980s. The deregulated industry responded with a spectacular network expansion on the one hand, and an increased consolidation on the other.

The year 1988 was one of the best years for the United States and the world airline industry, as revenue passenger miles and operating profits reached new peaks. When economic growth rates slowed toward the end of the eighties, so did revenue passenger miles and airlines' profits. It became apparent that the booming eighties were fading away. Then, in a move that largely ignored the business cycle and the industry's financial condition, the airlines placed the highest number ever of orders for new aircraft with manufacturers. These enormous financial commitments for new aircraft with the economic downturn of the early 1990s eliminated possible industry profits for the next several years.

This chapter examines aspects of strategic behavior with respect to aircraft as input in the air travel market. Strategic considerations played an important role both in post-deregulation interest group politics concerning safety and environmental regulation and in the airlines' motivation toward the end of the 1980s to order an unprecedented number of new aircraft.

The typical dilemma for an aircraft manufacturer is that it competes with itself; that is, it must replace an established and earlier version of a product it has sold. Older aircraft have turned out to be durable and efficient, and they thus constituted a significant part of the market. Older aircraft are extremely tough competitors for new models. The manufacturers actually became the victims of their own success, and adopted a strategy of fighting the market for the old aircraft in an attempt to promote demand for new aircraft.

[33] Levin (1996, p. 46).

Aircraft acquisition policies also played a strategic role in the developing competition among airlines in the air travel market. Fleet composition (in terms of newer- and older-generation aircraft) became an important strategic variable in airline competition as new generations of aircraft became available. This in turn affected airlines' production technology and cost. Post-deregulation diversity in fleet composition went hand-in-hand with acceleration of intraindustry heterogeneity in cost structure. It is traditionally the case that startups and small or less financially strong airlines, and charters and cargo airlines operate proportional older aircraft. The major financially stronger airlines operate more new aircraft. This heterogeneous fleet composition is associated with a heterogeneous industry structure and interest group structure.

The financially strong airlines, as a group, used this heterogeneity strategically by supporting government intervention and regulation that imposed a higher burden on the other airlines. Such a strategy raises the rival group's cost and poses additional barriers to new entry. The major airlines with the newer aircraft lobbied for a surtax based on fuel consumption, for example, because such a tax favors the newer, more fuel-efficient aircraft. Similarly, the major airlines operating the newer equipment supported safety and environmental regulations that were harder for older aircraft operators to meet.

Also, aircraft age emerged as a marketing tool. Airlines operating newer aircraft attempted to differentiate their product, suggesting that a seat on a newer airplane is better than a seat on an older one, safer and more comfortable. Actions like this played an important role in the post-deregulation airlines' strategic behavior.

Aircraft manufacturers and the major financially strong airlines (operating newer aircraft) came together to form an ad hoc coalition with a mutual interest of disparaging the older aircraft. During the last quarter of the 1980s, the industry embarked on an unprecedented regulatory effort directed at old aircraft. The cost of compliance often amounted to the market value of the aircraft at the time the regulation became effective.

At the same time, a great number of new aircraft orders were placed, while it must have been clear to the industry that economic growth was slowing down, that profits were declining, and that such a volume of new orders could not be justified unless there were a massive retirement of old aircraft. It was also clear that the old aircraft were still efficient in operation and not less safe than the new ones.

In a further turn of events, the new aircraft were not delivered until the early 1990s, when the industry was struggling with a major economic crisis, which ended with the demise or bankruptcy of several major airlines and further industry consolidation.

In this chapter I suggest that oligopolistic competition among manufacturers over market share in aircraft markets and among airlines over market share in air travel markets caused aircraft ordered during the late 1980s to be completely out of step with standard considerations of economic cycles or the demand for air travel. I focus more attention later on the specific environmental and safety regulation initiatives that targeted the older aircraft.

1. AIRCRAFT GENEALOGY

The introduction of US-built commercial jet aircraft in the late 1950s not surprisingly had a devastating economic impact on the previous generation of aircraft. The new jet engine-powered aircraft had longer ranges, higher speeds, greater seat/cargo capacities, and significantly lower costs per seat mile. But— they required many more passengers to break even. The surviving propeller-driven aircraft technology maintained only a marginal market niche in serving low-density short-haul markets, where they retained economic superiority over jet-powered aircraft.

1.1 First Generation

The first four-engine Boeing 707/720 aircraft were delivered in 1958, followed by the Douglas DC8s in 1959. In 1963, Boeing introduced the 727-100, a three-engine aircraft that was able to carry up to 129 passengers over short- to medium-range routes. In 1967, a stretched version of this aircraft, the 727-200, capable of carrying 170 passengers, was delivered, and in 1972, the first heavier version with an improved wing, called the B727-200 Advanced, came to market. The 727 was in fact a family of aircraft that could cover short to medium ranges with diverse engine intermix capabilities (Pratt & Whitney JT8D-7, -9, -15, -17), diverse weights, and possible modification with addition of extra fuel tanks that could extend its range.

In 1965 and 1967, Douglas and Boeing introduced (respectively) their DC9-10 and 737-100 twin-jet, short-range aircraft in the 100-seat category. These aircraft as well were subsequently stretched, to develop into a family of aircraft with more seat capacity and longer ranges. In the early 1970s, a new widebody technology was introduced, as the jumbo jet aircraft (Boeing 747-100/200, DC-10, and L-1011) were offered as replacements for the B707 and DC8 aircraft. Increased engine power, range, and seat-capacity made these aircraft suitable mostly for high-density coast-to-coast and international markets.

All these aircraft represent the general fleet in use when the airlines made their transition to deregulation. I refer to these airplanes loosely as either first-generation or "old" or "older" aircraft. I should also distinguish between the short- and medium-range single-aisle aircraft, which I call "small" or "narrowbody" aircraft (727s, 737s, and DC9s) and the long-range "large" or "widebody" aircraft (747s, DC-10s, and L-1011s).

1.2 Aircraft Age

Old and new are relative descriptors that have different meanings in different contexts. There is no avoiding metaphorical significance. For aircraft, people usually associate "old" with slowness, fragility, tendency to break down, high operating costs, high noise levels, and lower levels of safety. A commentator on a television talk show I watched was shocked by the fact that aircraft that are 15 years old are still flying. "I don't feel safe driving a 10-year-old car," she said. "Why would I want to fly in a 15-year-old aircraft?" To the uninformed, this conclusion may seem reasonable, but is the comparison correct? Maybe we should compare aircraft structure to the life of a bridge; after all, there are certain similarities in the design and maintenance of aircraft and bridge structures (by this standard, a 15-year-old aircraft is an infant in comparison with the London Bridge).

The first commercial jet aircraft, the British Comet, suffered several fatal crashes that were attributed to metal fatigue—this when the aircraft was barely one year into operation. The supersonic transport Concorde, on the other hand, was the oldest aircraft crossing the Atlantic (over 30 years old) before it ceased operation in 2004, yet perceived by both public and passengers as a technological marvel. When does an aircraft become too old for commercial use?

The industry's perception of age has all along been different from the public's. In fact, the industry has held that a properly maintained aircraft can fly forever. The industry's view says:

> there is no limit to the service life of Boeing damage-tolerant-design airplane structure, provided necessary inspections are carried out along with timely repair and or replacement of damaged structure or with preventive modification (Goranson and Miller 1989, p. 1).

The public, though, thinks that aircraft age directly and significantly affects safety. I would propose that no real effort has ever been put into educating the public or changing the perception that older aircraft are less safe, because it has supported the strategic interest of the largest major airlines and the manufacturers to disparage the old aircraft.

Aircraft age is typically measured by the number of total flight hours and cycles flown (one cycle is equal to one takeoff and landing). The number of cycles flown is usually a more critical measure than calendar age, because it reflects wear and tear and stress that are related to landings and takeoffs and cabin compression and decompression. Age measured in terms of calendar years only is less informative because it does not reflect an aircraft's actual use patterns.

When is an airplane old enough to be retired and replaced? The industry has adopted a two-dimensional framework for this question. One dimension is *mechanical life*, focusing mainly on maintenance and safety requirements. The second is *economic life*, focusing on the cost of maintenance.

1.2.1 Mechanical Life

With respect to the mechanical issue, the industry has adopted (and the government has formalized by regulation) the notion that design and production requirements together with continued and systematic maintenance, monitoring, and modification of aircraft in operation must produce an infinitely safe mechanical product. Regulation requires manufacturers to comply with quite strict requirements of "fail-safe" and "damage-tolerance" standards in designing and building aircraft. These standards require structural and system redundancy (including system multiplicity and backups), significantly enhancing an aircraft's ability to recover in case of failure.

Extensive testing of structures and systems is required prior to certification by the FAA for commercial use, and mandatory maintenance requirements are imposed on an aircraft in commercial use. It is the airline's responsibility to obtain the FAA's approval for both its specific maintenance program and the manuals that it develops based on the aircraft manufacturer's recommendations. Continual monitoring and review by the regulator, the operator, and the manufacturer are required once the aircraft enters service.

Defects and problems that occur during normal operation or that are revealed in incidents and accidents are evaluated by the industry. Usually they trigger a recommendation by the manufacturer, typically in the form of a Service Bulletin (SB). When such recommendations have airworthiness implications, they are issued as mandatory regulations, usually as Airworthiness Directives (ADs) or Federal Aviation Regulations (FARs). If an aircraft type exhibits recurrent problems that may be associated with faulty design, specific mandatory modification of the aircraft is triggered. Problems can trigger the grounding of an entire fleet or class of aircraft, or even a Special Certification Review (SCR) by the FAA.

Ongoing maintenance is usually conducted by the airlines on a routine scheduled basis, as well as a non-routine basis. Non-routine maintenance addresses specific discrepancies if any, before during, or after scheduled maintenance. Maintenance checks of aircraft are performed at mandatory scheduled intervals. During scheduled and recurrent structural checks, the fuselage is inspected and repaired, and parts of the structure may be replaced. Critical parts and components of airframes and engines are limited by hour or by cycle of utilization and/or calendar time, and must be overhauled or replaced at mandatory intervals.

Avionics and other equipment are continually updated and upgraded according to mandatory FAA requirements and an airline's own configuration standards. For example, all commercial aircraft of any age must comply with current requirements for ground proximity warning system (GPWS); traffic and collision alert system (TCAS), windshear alert systems, and flight data and voice recording systems (FDR and FVR). Many airlines have installed new global positioning satellite (GPS) navigation systems as they have become available.

An airplane might be 20 years old, but many of its systems have been updated, upgraded, and routinely overhauled or modified. An engine goes through a similar process. All its critical life-limited parts are replaced at mandatory intervals with new and/or overhauled parts. Hot-section parts are replaced periodically, and other parts and components are overhauled or replaced during scheduled maintenance. It is conceivable that the only original part in an old JT8D engine, for example, is the identifying placard (showing the serial number) attached to the gearbox, because all other parts and components have been replaced during years of maintenance. How would we define the age of such an engine?

Any aircraft and engine maintenance work must be performed by FAA-regulated and certified personnel and entities, whether by airlines or by outside vendors. Similarly, all parts, components, and repair and testing tools and equipment, as well as manufacturing, inspection, and repair procedures, must be certified and subject to FAA regulation. In general, the FAA must certify a repair shop (whether an airline's or an independent firm's), and the airlines must audit and monitor the performance of the shop according to established standards. The FAA monitors and enforces performance of both the shop and the airline.

1.2.2 Economic Life

The second dimension of aircraft age is its “economic life.” An aircraft becomes obsolete if its operating cost exceeds the cost of a newer competing aircraft. This could happen if a superior new technology is introduced. As we have noted, the introduction of jet engine technology made most propeller-powered aircraft in the 1960s uneconomic for operation almost overnight. The introduction of the second generation of jet aircraft during the 1980s was expected to cause retirement of many first-generation aircraft because of the newer aircraft’s lower fuel consumption. Or, an aircraft may become obsolete if the maintenance costs necessary to keep it airworthy rise above a certain level.

One of the major cost disadvantages of an older aircraft is generally higher maintenance costs. Older airframes are more susceptible to metal fatigue and cracks because of stress and corrosion. They thus require more inspection, more repairs, and more aircraft down time for maintenance. All things equal, an older aircraft is more expensive to maintain, and the cost increases with increased use (age) of the aircraft.

1.3 Second Generation

The second generation of narrowbody aircraft was introduced to the market during the first half of the 1980s, starting with the MD80—a stretch version of the DC9 with new and more powerful engines. In 1982, a new, longer-range, higher-capacity (one-aisle) aircraft—the 757—was delivered, and in 1984, Boeing ceased production of the 727 and started to deliver a new family of 737 aircraft (designated B737-300, -400, and -500). The new Boeing 737 and 757 aircraft covered the markets previously served by the 737s and 727s. Among the larger aircraft produced in 1982 was a smaller twin-engine (double-aisle) model 767 that could carry over 250 passengers between 3,100 miles in its shorter-range version to over 6,000 miles in its later extended-range version.

The second-generation aircraft were designed following the oil crisis of the 1970s. Reducing fuel consumption was a major design challenge. It was achieved primarily by developing a new generation of high bypass engines, producing higher thrust at lower fuel burn levels. In addition, new digital technology and increased automation reduced pilots’ workload and required only two cockpit crew members instead of three. The expectation was that the savings due to lower fuel consumption, smaller flight crews, and reduced maintenance expense would justify retirement of first-generation aircraft and the acquisition of new second-generation aircraft.

The 727 had been the best-selling Boeing airplane, with 1,832 units produced. Its production line was closed with the delivery of the new 737-300/400 aircraft in late 1984. The three-engine, three-person cockpit, 727 was expected to be the main economic casualty of the newer more efficient family of 737 aircraft. Boeing adopted the 737 designation for the new generation of its aircraft, and abandoned the designator 727, the most popular of its aircraft. The company expected that an accelerated retirement of the fuel guzzling 727 aircraft would create significant demand for its new family of 737 and 757 aircraft.

The new 737 airframe was a descendant of the first generation 737-200 aircraft. Its fuselage was extended to accommodate up to 149 passengers, and new and more fuel-efficient (CFM56-3) engines were installed.[34] For passengers, the new 737 aircraft had a look and performance (in terms of speed and range) very similar to the previous generation of narrowbody aircraft. Its ability to effect significant retirement of older-generation aircraft was thus critically dependent on the market behavior of oil prices.

1.4 Oil Prices

The pendulum swing of oil prices during the 1970s and 1980s is important for our understanding of the story. In ten years, oil prices increased over tenfold, from under $3 per barrel at the end of 1972 to $34 in 1981 (jet fuel increased from 11 cents to $1.14 per gallon) Boeing (1991, p. 14). The operation of first-generation aircraft, designed in the 1960s before oil became such a major issue, suffered significantly in the 1970s from oil price behavior. Reducing fuel consumption constituted the major design challenge for the new-generation aircraft designed in the late 1970s (the MD80s and 757s) and the early 1980s (the new 737), when oil prices reached their peak. Then, starting in 1981, the oil price trend reversed itself through most of that decade (see Figure 4).[35] In fact, jet fuel prices dropped by almost one-half (in real terms) between the peak level in 1981 and the average level during the second half of the 1980s.

Newer, expensive aircraft, designed with the objective of cutting fuel costs, were introduced into a falling fuel price world that dissipated most of their economic advantage.

Demand for the old narrowbody aircraft increased significantly starting in the early 1980s and throughout the decade. This occurred not only because of the general boom in demand for domestic air travel and falling oil prices, but also because of structural market changes. One reason was the development of hub-and-spoke networks. Longer routes came to be served by a combination of shorter ones connected at a hub. Economies of density and scope at local hubs required greater seat capacity and replacement of smaller commuter aircraft with larger jet aircraft in this category. (The DC9 and B737, for example, were ideal hub aircraft in the 100-130-seat category.) More destinations served from hubs, as well as a significant increase in frequencies of flights, required more aircraft.

[34] Produced by a joint venture between GE and the French company, Snecma.

[35] Jet-fuel cost per gallon, 1972 price = 100. Source: American Transport Association.

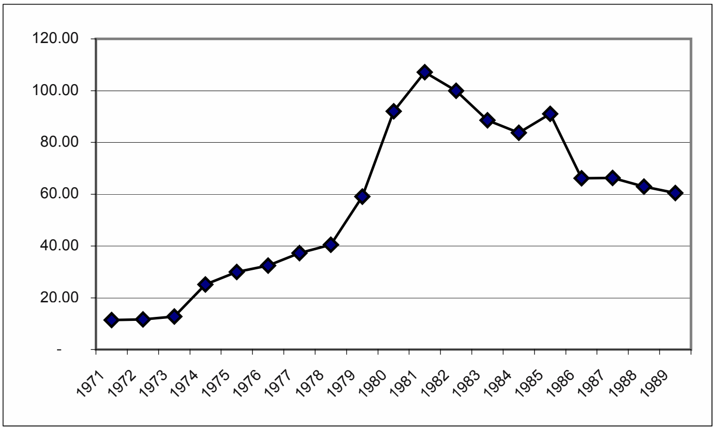

Figure 4. US Airlines Fuel Price Index

In addition, older, narrowbody aircraft were in demand by the new startup airlines that attempted entry into the market during the 1980s. A fascinating phenomenon was the almost overnight explosion of a new market for small packages and overnight mail service, led by Federal Express. This market used a hub system with relatively more demand for short- and medium-range aircraft, and absorbed a large quantity of older aircraft, mostly 727s, which happened to have a relatively high volumetric efficiency for this specific cargo.

With declining fuel prices, the durability and reliability of the older-generation aircraft and the dramatic expansion of the deregulated market kept demand high for these aircraft throughout the 1990s. During the recession period of the early 1980s, approximately 800 older-generation aircraft were retired. Most of them were disassembled for parts that were used to support operation of the surviving first-generation aircraft.

2. AIRCRAFT ECONOMICS

Declining oil prices were a major factor in maintaining high demand and prices for the old narrowbody aircraft. In fact, prices of certain old narrowbody aircraft more than doubled between 1981 and the middle 1980s. The difference between the acquisition costs of the old 737-200 or 727 aircraft and the new 737-300/400/500 or 757 aircraft, however, did not justify accelerated retirement of older planes. With the relatively low oil prices, the difference in operating cost was not enough to justify the difference in ownership cost. This experience was much like the one for automobiles during the early 1980s; the incremental acquisition cost of a fuel-efficient Japanese car did not justify the dollar value of the gas savings compared to a less-efficient American car.

2.1 First- vs. Second-Generation Aircraft

Table 1 reflects comparative operating data of first-generation versus second-generation narrowbody aircraft for the quarter ending December 31, 1989, extracted from an industry publication.[36] It breaks down operating costs per hour of aircraft utilization by standard industry cost categories.

Table 1. Operating Data 1st Versus 2nd Generation Aircraft

	DC9-30	737-200	727-200	737-300	757-200
Flying:					
Crew	405.00	380.02	493.56	371.77	481.83
Fuel	545.00	539.54	854.93	507.90	667.41
Insurance	4.00	4.41	3.96	6.48	11.61
Other	2.00	0.75	2.11	0.08	0.01
Total	956.00	924.72	1,354.56	886.23	1,160.86
Maintenance:					
Direct	285.00	259.51	322.25	219.24	267.15
Burden	159.00	120.14	212.81	93.35	84.51
Total	444.00	379.65	535.06	312.59	351.66
Total	1,401.00	1,304.37	1,889.62	1,198.82	1,512.52
Dep/Rent	280.00	329.13	263.00	499.57	590.93
TOTAL	1,681.00	1,633.50	2,152.62	1,698.39	2,103.45
Load Factor %	57.39	57.90	58.61	58.84	60.25
ASM	102.60	110.00	147.90	130.50	186.90
Cost S/H	16.48	16.78	14.56	13.01	11.26
Use (Hr)	6.70	7.30	7.50	8.60	9.10
Flight Length	415.00	432.00	669.00	586.00	652.00

According to the publication's calculations, total direct operating cost of the second-generation aircraft analyzed was 8% lower than the cost of the older-generation aircraft. This difference is explained mostly by lower fuel consumption. The ownership cost component (depreciation and rent), however, is significantly higher for the newer-generation aircraft, making up nearly 28% of the total direct

[36] Source: *Air Transport World*, "Aircraft Opearating Data" October 1990, p. 150.

operating cost for the new generation, compared to only 14% for the older-generation aircraft.[37]

A comparison of cost per seat mile across the aircraft shows that the new 737 and 757 aircraft are more efficient than the older-generation aircraft. The 757, for example, consumed approximately 250 gallons less in fuel per hour compared to the 727 (representing a savings of approximately $188 at 1989 fuel prices). The new digital ("glass") two-person cockpit saves an additional almost $12 per hour over the 727. These savings reflect the major advantage of the new aircraft technology over the old one. The 757 is equipped with two engines that generate more thrust at less cost than the three old JT8D engines installed on a 727. In addition, the 757 can carry more passengers on longer-range routes.

Cost differences are highly dependent on jet fuel prices, however. Table 1 reflects airlines' accounting for the last quarter of 1989, when jet fuel prices were slightly above 60 cents per gallon. Obviously an increase or a decrease in cost per gallon can change the picture either way.

The data in Table 1 are average accounting (historical) data. Accounting ownership costs depend on somewhat arbitrary depreciation assumptions. They do not reflect cash flow and cannot tell much regarding the cost of adding the next (marginal) aircraft to a fleet.

For purposes of illustration, assume that an airline contemplates adding an aircraft to its fleet.[38] Table 2 reflects average market values and monthly rents for various aircraft types in December 1989.[39]

Table 2. Aircraft Market Value and Rental Rates

A/C	DC9-30	737-200A	727-200A	737-300	757-200
Value	6,500,000.00	6,750,000.00	6,000,000.00	20,000,000.00	30,000,000.00
Rent	100,000.00	100,000.00	110,000.00	250,000.00	375,000.00
Monthly Hr	201.00	219.00	225.00	258.00	273.00
Rent per Hr	498.00	456.62	488.89	968.99	1,373.63
Total Cost	1,401.00	1,304.37	1,889.62	1,198.80	1,512.52
TC + Rent	1,898.00	1,760.99	2,378.51	2,167.81	2,886.15

[37] The publication includes in its 14% rate other aircraft that are not included in Table 1.

[38] While general industry statistics are quite useful for illustrating these points, they are far from accurate. For example, the airlines are viewed as a coherent industry, and airline-specific aspects are ignored. They show reported costs, given a certain route allocation. 757 routes, for example, are longer, and therefore expected to cost less per hour. Also, aircraft are assigned to different routes with different levels of demand and load factors. A specific comparison analysis requires specific route analysis.

[39] Compiled from industry publications.

The monthly rent is divided by the actual average flight-hour utilization for the respective aircraft from Table 1 in order to normalize the rent per hour. The resulting hourly rent cost is substituted for the hourly depreciation/rent cost in Table 2, in order to indicate the expected market cost of operating an additional aircraft (as opposed to historic rent or accounting depreciation). Table 2 shows that when market rents are considered, the new-generation aircraft lose their attractiveness.

Another important issue is evident from the operating statistics. The second-generation 737-300 and the 757-200 aircraft average operation costs reflected in Table 1 are based on significantly higher average monthly utilization. 757 and 737-300 aircraft are operated roughly 20% more (hours) than 727s and 737-200s. The 757 and 737-300 are far more expensive, and lose much of their economic attractiveness if they are operated at lower average utilization rates. At an average utilization of 200 monthly hours, which is the traditional average utilization of most non-major hub airlines, they may not break even with current average load factors. When a high level of utilization is required in order for the economics of the new aircraft to work, only high-frequency scheduled airlines can justify acquiring them. Moreover, the cost statistics show that the load factors of the 737-300 and the 757 are higher than load factors for the old aircraft.

The industry in fact assigned the new-generation aircraft to higher-frequency, higher-density, operations. High utilization and load factors would be required to reduce the high fixed ownership cost of the new aircraft. Such an operational profile could be achieved only in a major hub operation or in an otherwise high-use high-density linear route network. The economic rationale behind this observation is the increasing return to scale and density. A significant part of aircraft operation cost is its fixed acquisition cost. In fact, if one considers the rental cost of an aircraft on the margin (Table 2), this is the greatest cost component. For old aircraft, the fixed acquisition cost is small relative to the variable operating costs, so lower utilization levels are sufficient to amortize the cost. The operational principle of new expensive aircraft is straightforward: They must spend most of the day in the air serving high-density routes in order to amortize their high ownership cost.

2.2 Second Generation Aircraft and Hub Operation

The importance of utilization rates are not always understood, particularly by observers who may not be directly involved with these issues. It was conventional wisdom at the time that the new aircraft are more efficient to operate than the old ones. In fact this is a myth. The conclusion is true only if the new aircraft are operated at high levels of use on routes that can support relatively high load factors.

I have been approached several times by non-major hub operators interested in acquiring new aircraft, encouraged by general industry statistics and manufacturer presentations suggesting that the new aircraft would be more profitable than the older ones. The operators were disappointed to find out that this perception is not borne out when they plug their actual cost and market data into specific route plans. As a general observation, the operations profile necessary to justify purchase of the new expensive aircraft could be achieved only by a major airline in a major hub where high frequency and economics of density and scope reduce the average ownership cost. Southwest Airlines is an exception, because of its unique ability to achieve very high levels of aircraft utilization (the industry's highest) with high load factors on its linear routes.

Major hub airlines can generally offer high flight frequency and density out of their hubs. Hub operations facilitate increased aircraft utilization and load factors. The uniqueness of Southwest's strategy is that it targets niche markets that are less congested but have sufficient demand to justify high-utilization, high-load factor, linear route systems, while eliminating aircraft ground time and improving aircraft utilization. With high operational efficiency of ground and aircrew systems, Southwest has achieved remarkable economic success by producing the highest production rates from its fixed-cost production capacity.

The requirement for relatively higher utilization rates and load factors makes the new aircraft more susceptible to cyclical downturns. First, load factors traditionally decline during recessions. In addition, reduced utilization due to falling demand does not change airlines' commitments to pay rent or make loan payments for the acquisition of the new aircraft. Older aircraft are more expensive to operate (while less expensive to own) so reducing utilization rates during a recession reduces the major cash outlay of operating an old aircraft. The major cost component of a new aircraft is the ownership cost, however, which must be incurred irrespective of the economic cycle.

This background is important for an understanding of the ad hoc coalition that developed in the late 1980s between the manufacturers and the major airlines.[40] Expensive new aircraft could be acquired and operated most profitably mainly by major hub airlines. Small, cargo, charter, and startup airlines, as well as low-frequency linear or other non-hub major airlines came to be largely excluded from the market for new aircraft. It was in the manufacturers' interest to instead support major airlines with highly concentrated hub systems and high-frequency, high-density operations, in order to sell new aircraft. The hub-and-spoke network systems were a necessary condition; they provided a combination of high utilization (frequency) and high load factors that could justify the high acquisition cost of new technology aircraft.

This essential connection between expensive new aircraft and hub technology is often overlooked by industry observers and is worth emphasizing. Buying new aircraft mandates a high fixed cost.[41] Yet the savings of the new technology were not sufficient to justify large-scale retirement of older aircraft or to otherwise significantly reduce average operating cost. Under regulation, increases in new aircraft prices and capacity were met by increased airfares. Following deregulation, increases in new aircraft prices along with high labor costs and falling airfares required increased aircraft utilization and load factors, and these were delivered

[40] The situation changed in the early 2000s. The manufacturers cut prices of new aircraft, and a new coalition was formed with startup airlines. See Chapter 8.

[41] A new 737 aircraft, for example, in the late 1980s cost an average of $30 million; a new 747-400 cost in the $130 million range. Once an aircraft is acquired, its rent or ownership cost is unavoidable.

mainly by complex hub-and-spoke systems that supported high flight frequencies and generated benefits of increased scale, scope, and density.

The conundrum is that the integrated hub-and-spoke systems involved high fixed costs in infrastructure and other assets mostly of a high sunk cost nature (besides aircraft). Attempts to reduce average cost encouraged an increasing production scale; more aircraft acquired and operated as well as more flight-hours used and more spokes served, which further heightened density and scope. These are important relationships to be recognized between new aircraft technologies and hub networks. These dynamic relationships contribute to the airline industry's tendency to consolidate and concentrate while expanding networks.

A somewhat analogous tendency characterizes the aircraft manufacturing industry. Aircraft design and building involves increasing-return technology due to steep learning effects, high fixed costs in design and development of new technology, and economies of scale and scope. A major portion of the cost in aircraft production is the fixed cost associated with developing and building a prototype, particularly when a new type of aircraft is developed (a 747, or a 777, for example), but also when derivatives in a class are developed (the 737-300/400/500, for example). The increasing-return nature of aircraft production encourages manufacturers to accelerate sales and increase their market share. In general, the cost of aircraft development and design (in proportion to actual production cost) has risen with the introduction of new aircraft technology, and it has become necessary to sell more units in order to amortize this cost and reduce its average level. The extent of aircraft sales, however, is constrained by the overall size of the market and the competition's share in it. Given then-expected market growth rates and the increased competition from Airbus, accelerating the retirement of previous-generation aircraft played an increasingly important role in manufacturers' strategies starting in the late 1980s.

One implication is that a smaller market for new aircraft or a stagnant one, in the face of growing development costs of new technology, tends to increase concentration in the aircraft manufacturer industry. We see an example in the debate concerning the economic viability of designing and building a new "super jumbo" aircraft. Analysts believe there is room for 500 such aircraft in the international market. Airbus officials estimated the development cost at about $12 billion, and projected 250 units would need to be sold over nine to ten years in order to break even. Boeing officials estimated the development costs at up to $20 billion, which would require almost 500 units to be sold in order to break even. It is quite clear that there is no room for more than one manufacturer in this market. If Airbus ventures into such a project (as it eventually did), it faces the risk that Boeing would develop a 747 derivative at a lower development cost and/or reduce significantly the price of its 747-400, which would make the potential market smaller for Airbus. A joint venture between Airbus and Boeing is a possible solution to this dilemma. Consider still that airlines that would buy such aircraft at an estimated cost of $230 million per unit would need considerable market share and a feeder network system that would allow the necessary load factors and utilization levels to justify such high fixed cost.

3. AIRCRAFT ORDERS

Falling oil prices and the high mechanical reliability of the first-generation aircraft caused retirement rates of those airplanes to be very low, significantly lower than the manufacturers' predictions. The first new 737-300 aircraft were delivered only at the end of 1984, and the 737-400 in the summer of 1986. The old aircraft flew during the first part of the unprecedented market growth of the 1980s before the new 737s were available. MDC delivered its MD80 in 1980, and by the time the new 737-300 was delivered, approximately 200 MD80 were in operation in the industry.

Competitive pressures were also exerted by Airbus. The European consortium penetrated the US market in 1977 with its A300 model aircraft, originally designed for high-density, short- to medium-range markets. Over 30 aircraft had been delivered to US airlines (particularly to Eastern Airlines) by the time the first new 737-300s were delivered at the end of 1984. Airbus took aggressive marketing steps in an attempt to penetrate the world market in general as well as the US market.[42] The first versions of the A300 were intended to provide the attractive economics of high-capacity (widebody) aircraft on short/medium routes, but this contradicted in some respects the strategic move to hub systems, which required high-frequency operations. Subsequent versions of the A300 extended its range and made it more suitable to longer linear routes. At the beginning of 1984, Airbus started designing the A320 aircraft, in direct competition with the new 737 family. This move together with an increasing market share for Airbus aircraft mostly in foreign markets made the Airbus threat more serious.[43]

In 1986, orders for new aircraft dropped significantly for the first time since the early years of the decade, mostly with respect to new narrowbody 737 and 757 aircraft. In 1986, orders for 737s fell from 253 in the previous year to 199 and in 1987 to 170, while the number of orders for 757s fell from 45 in 1985 to 13 in 1986. At the same time, the average retirement rates of older aircraft dropped to approximately 40 aircraft per year, the lowest since the mid-1970s.

With the last quarter of the 1980s, it became clear that the long economic boom and the unprecedented industry expansion of the 1980s were both coming to a halt, as the economy and airline traffic growth rates together started to decline. Orders for new aircraft declined as well. Figure 5 plots the total number of aircraft orders (per year).[44] The number of yearly orders for new jet aircraft more than tripled in 1986 compared to 1983. In 1987, orders fell from that peak. It was clear to the industry at the time that market expansion by itself would not create enough of a demand for new aircraft orders. The manufacturers realized that accelerating the retirement rates of older aircraft would be necessary in order to generate orders for new aircraft. Stubbornly, the older aircraft exhibited strong market resiliency. It is at that point that the manufacturers adopted an aggressive marketing policy of killing the market for the old-generation aircraft. They took aggressive marketing steps to persuade airlines to order new aircraft, and they encouraged the retirement of older equipment

[42] Airbus delivered aircraft to EAL and waived rent payments for several months of operation.

[43] Braniff placed the first US order for 110 A320 aircraft with Airbus during 1986.

[44] Source: *World Jet Airplane Inventory Year End 1990*, Boeing Commercial Airplane Group.

by pushing for additional safety and noise regulation aimed specifically at those aircraft.

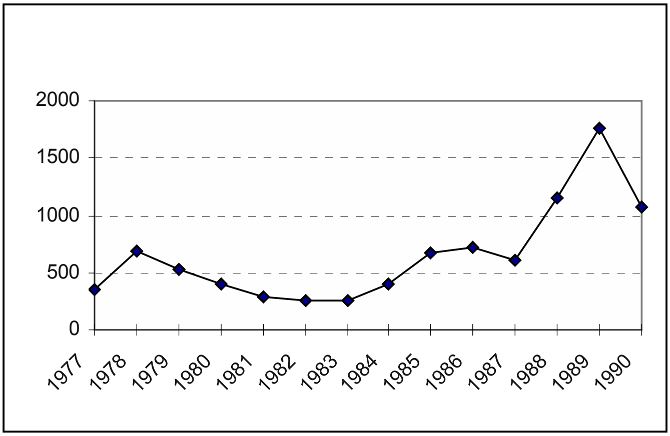

Figure 5. New Aircraft Orders

In a move that impacted the aircraft market in a dramatic way, the industry in 1989 placed an unprecedented number of orders for new aircraft. The number of aircraft orders placed in 1989 was almost three times the number in 1987, amounting to 1760 units. Altogether, the number of aircraft orders placed with the manufacturers during the last three years of the decade represented over 40% of the total aircraft inventory in commercial use in 1989. In dollar terms, orders of $54 billion were placed in 1988, of $96 billion in 1989 (a 78% increase over the record level of the previous year), and of $81 billion in 1990 (current dollars, according to Boeing Outlook, 1991). In 1990, Boeing reached its all-time high volume of orders: $51 billion. This enormous volume of orders was placed despite a significant drop in the world air travel growth rate (measured in revenue passenger miles, RPMs) from about 10% in 1987 to about 5% in 1989, and despite a similar expected trend in world GDP growth rates and in airline profits.

3.1 The Manufacturers' Problem

In the standard model of a market, products are assumed to be perishable. The completion of production, sale, and consumption of a product is an instantaneous event; the product is sold, and disappears forever (aircraft seats on a specific flight are a good example). The picture is different, however, for the firm that manufactures a durable good. Once the product is delivered to the market, it competes with demand for a new version of the product. A manufacturer of a durable good may have to fight for market share against its own product that it has sold previously. This fight is harder, the better and the more durable the old good is. The manufacturer's strategic and tactical decisions today affect both the current market for used versions of the previously delivered product and the future market for a new generation of the durable good the manufacturer expects to sell in the future.

Introduction of a new edition by a book publisher is an example of such intertemporal relationships. In general, the more significant the additions to and the modifications of the new edition, the higher the demand for this edition is expected to be. Pricing, advertising, product characteristics, and other strategic decisions made by the manufacturer in one period may conflict with its objectives in the second.

Ronald Coase has generated a theoretical debate regarding such intertemporal aspects of pricing by a durable-good monopolist. Coase's major insight is that durability might reduce monopolistic power. Since maximization of revenues implies that only a part of the product stock is sold every period (Coase uses land as an example), the monopolist incentive is to cut prices every period. Yet, since consumers are aware of such behavior, they may refrain from purchasing until the price comes down.

Coase's idea that durability erodes monopolistic power is based on his perception of buyers' strategic understanding of and response to the monopolist's behavior. A monopolist's systematic policy of intertemporal price discrimination is transparent to buyers, and they will not facilitate it (assuming there are no costs or any other consequences to waiting for the price to drop). Lease, buy-back, tie-in, trade-in, and other contractual arrangements that reflect credible commitments to maintain prices may enhance monopolist power. But even this is not for sure, transmitting credible commitments to buyers regarding high pricing may encourage entry and competition by other manufacturers. Similarly, the manufacturer's decisions regarding the durability of the product may affect its market power in the next period.

Will monopolistic manufacturers systematically build in lower durability for their product than for competitors' products? Will they overinvest in R&D in order to destroy the used version of the durable? Will competitive producers behave differently from a monopolist? Will they support regulation to reduce the value of the used versions of their product?

It is instructive to focus on three major questions: First, can an aircraft manufacturer affect the durability of its product in a significant way, given the stringent durability and safety standards imposed by the regulator? Second, is killing the market for used aircraft by, for example, promoting regulation necessarily in the manufacturer's best interest? Third, if we answer yes to the first two questions, what would the buyers, the airlines, do? It is highly unlikely that airlines would not see through such a strategy. How would they react?

3.1.1 Can an Aircraft Manufacturer Affect Its Durability?

Manufacturers can affect the market value of an old version of their product in several key ways: first, by developing and offering a new product or technology that changes the market for the old version; second, by strategic pricing; and third, by directly affecting the value of the old version of a durable through after-sale support contracts, maintenance and repairs, warranties, and so on. Support of regulation initiatives that are expected to impact the economic life of the old version of the durable can directly influence its market value as well.

Aircraft manufacturers are uniquely positioned to impact the economic durability of used versions of their aircraft through their important role in directing the operation and after-sale support of used aircraft.[45] All operational, maintenance, modification, and repair activity related to aircraft (or engines or any part or component) is directly controlled by the manufacturers. In most cases, manufacturers' recommendations set the required standards for operation and maintenance of aircraft. Changes in aircraft configuration or modification by airlines require the manufacturer's approval and the purchase of proper documentation. The manufacturer also controls spare parts support. Manufacturers continue research, testing, and development of techniques, procedures, improvements, and modifications of aircraft long after their delivery, in parallel with the marketing of new generations of aircraft. They participate in the investigation of accidents and the development of safety procedures and actions to guard against accidents. Safety-related service bulletins issued by manufacturers are usually enforced by the FAA as legally binding regulations in the form of Airworthiness Directives (ADs), Federal Aviation Regulations (FARs), or otherwise. Issuance of a safety-related Service Bulletins (SB) triggers an immediate regulatory response, and in most cases is translated almost automatically into a mandatory AD. Some airlines or civil aviation authorities require compliance with certain SBs even if they are not adopted as mandatory ADs by the FAA.

Manufacturers may initiate new regulation, or respond to demands for new regulation initiatives by other players. They are an integral part of the regulatory process. Indeed, the institutional core of the regulatory process is the manufacturers, the airlines, and the FAA, each player with its particular interests, information, and political power.

Aircraft manufacturers' power in the regulatory process stems to a large degree from their specialized information regarding aircraft design and production in general and in particular regarding their own product. Their expertise is in developing and researching aircraft structures, for example, and they have extensive budgets, engineering capabilities, and other resources to deal with these issues, more than many other players in the regulatory process.

It is, for example, highly unlikely that an airline or a consumer organization would invest resources in wind tunnel testing in order to study the long-term structural integrity of an aircraft. This is the kind of activity that a manufacturer would engage in.

[45] This is in addition to other strategic policies such as advertising, R&D, or pricing of new products..

Additionally, in most cases the manufacturer is the only provider of the after-sale technical and engineering support to an aircraft, including, for example, the parts and documentation that are necessary in order to comply with an SB issued by the same manufacturer. The manufacturer by and large enjoys a perfectly monopolistic position in this market as the sole source of these services.

3.1.2 Is Killing the Market for Used Aircraft in the Manufacturer's Best interest?

Do producers of durable goods in general benefit from supporting legislation and regulation restricting the market for used versions of their durable product? Do aircraft manufacturers benefit from killing the market for old aircraft? Economic theory deals with such issues quite extensively, but no clear-cut results have been suggested.

The traditional line of reasoning, which can be traced back to the decision in United States v. Aluminum Co. of America, is that new and used versions of a good are substitutes. Used versions of a product capture a portion of the market and stand in the way of sales of new product. The manufacturer competes with the used versions of its product as a substitute product; everything else equal, its incentive to limit the used product market is positively related to the elasticity of substitution.

The first- and the second-generation jet aircraft are close substitutes, and there is no doubt that first-generation aircraft captured (and still capture) a part of the market that otherwise could be served by new aircraft. On this basis, it would not be unexpected that the manufacturers would attempt to kill the market for old aircraft. The manufacturer's policy, however, is known or otherwise understood by the market. A move by manufacturers to limit the use of an older version of the aircraft or otherwise impose additional costs through regulation will be evident to the airlines and will be incorporated in the market price.

Economists call this the "present value effect." The market value of a durable reflects the present value of the stream of income it is expected to generate, including its future resale or scrap value. A general manufacturer policy to diminish the future value of used aircraft must therefore be reflected in the demand for and the market price of the new aircraft. The present value impact acts in an opposite direction from the substitution impact, and the manufacturer's ability to benefit from such a policy depends on these as well as the location of the supply curve.

A move by a manufacturer to undermine the market for used aircraft will also affect the industry supply curve and therefore its size and concentration. Because new and old aircraft are substitute factors of production, increasing the cost of operating older aircraft would be expected to change the industry fleet mix, production function, and supply curve. Costs imposed by such regulation can be interpreted as a tax on old aircraft. Regulation can increase the fixed cost of operating old aircraft and/or the operating variable costs.[46]

[46] For example, stage III noise regulation of a 727-200 aircraft required a one-time modification cost of almost $3 million. In contrast, part of the Corrosion Prevention (CPCP) and Supplemental Structural Inspection Document (SSID) regulations require recurrent inspection and modification overtime often as a function of aircraft flight time/cycles.

New aircraft are more expensive to acquire and less expensive to operate than older ones, so imposing regulation on old aircraft is expected to increase both their cost and the demand for new aircraft, causing the industry's fixed cost to move up (everything else equal). Assuming a negatively sloped demand curve for air travel, regulation is expected to dampen industry production. Increasing the cost of old aircraft also raises the financial barriers to entry by new airlines. Traditionally, new entrants acquire older, less expensive aircraft. Increasing the cost of older aircraft makes entry more expensive.

One of the arguments in favor of deregulation in the middle 1970s was that the *capital threshold of entry* into the industry was relatively low due to the availability of used aircraft that could be acquired or leased for significantly less than new aircraft. In its analysis of the industry the CAB argued:

> The potential entrant can reduce the capital threshold in a given market through the purchase of used aircraft, at a cost some 10 to 40 percent or more below that of comparable new equipment (CAB, 1975, p. 110).

Indeed, the availability of highly reliable old technology aircraft at significantly lower prices did make the entry threshold relatively low during the 1980s. Imposing aging and noise regulations directly affected the acquisition cost of old aircraft and raised the threshold costs of entry.

Is increased industry concentration in a manufacturer's best interest? There is no clear-cut answer to this question either. The smaller, financially weak, cargo and startup airlines are expected to be proportionally more affected, and because these airlines usually don't acquire new expensive aircraft, it is arguable that an industry contraction may not affect current new aircraft sales. Yet increased industry concentration may reduce the demand for new aircraft in the future, and may enhance the surviving major airlines' bargaining power with the manufacturers with respect to new aircraft acquisition in the future.

One other important element makes the decision to kill the old aircraft even more complex. The after-sale support of aircraft is a source of revenue for manufacturers, and therefore regulation aimed at modifying and fixing old aircraft creates an opportunity for additional revenues. It is not generally clear, and it is quite difficult to predict, which of these conflicting effects is the stronger, and what their overall long-term impact is.

Boeing, for example, which was best positioned to develop noise abatement technology for its aircraft, elected not to take part in this activity. Therefore, an aircraft modification that is normally treated as a manufacturer SB was left to other market players to develop and sell. Federal Express, a major operator of 727 aircraft, for example, developed noise abatement kits for installation on its fleet of aircraft and sold them to the market as well. It enjoyed a monopolistic position in this market for almost ten years while Boeing conceded a significant source of revenues in the after-sale market. Unlike Boeing, MDC elected to support its DC9 aircraft; it offered, among other things, a life extension program that included structural enhancement and engine upgrades, and it participated in the design and sales of noise abatement kits. Similarly, Boeing did not take a competitive position in the market for converting 727 aircraft into cargo configurations, and thus other companies entered the market.

It is interesting to note that, in general, Boeing adopted a more aggressive position toward killing its old aircraft than MDC. It provided the minimum required support for the after-sale market, and not much more. To the extent that Boeing's policy did encourage the sales of new aircraft, sales would have come at the cost of giving up potential additional income from the support of older-generation aircraft.

Competition among aircraft manufacturers plays an important role as well and is worth further emphasis. The hegemony of the United States in the commercial jet aircraft market started with introduction of the Boeing 707 in the late 1950s. In 1974 Airbus delivered the first four A300s, and in 1977 it penetrated the US market and delivered the first A300s to Eastern Airlines. In 1983, the A310 series was introduced, and in 1985, the first four aircraft were delivered to a US operator. The first A320s were delivered in 1988 and during the next year the first aircraft deliveries were made to the US market.

Toward the end of the 1980s, the European threat became serious. Airbus's share of the US market was small but not negligible, and grew slowly during the 1980s with over 100 aircraft deliveries by the end of 1990. Airbus could only benefit from the destruction of the old aircraft, since none of its aircraft fell into that category. It was obvious that killing the old aircraft would affect mainly US manufactured aircraft, and Airbus targeted this segment of the market.

The European public views aircraft noise as a major environmental issue, and European governments responded to demands by high-profile environmental movements by pushing for aggressive noise reduction that targeted old US manufactured aircraft. Europe in fact became the political leader in pushing for stricter noise regulations. It is also noteworthy that during the second half of the1980s new Airbus aircraft sustained above-normal accident rates, a fact that raised questions regarding the safety of the new technology incorporated in the aircraft. It was obviously expedient for Airbus and the European governments that own and control the consortium to focus attention on (US manufactured) old aircraft as a major safety and environmental hazard.

It is not a priori clear whether the decision of a manufacturer to kill the old version of a durable in general, or old aircraft in particular, is beneficial on a theoretical or practical basis. A critical element in the decision for aircraft manufacturers in reality was perhaps the importance manufacturers assigned to revenues generated by selling new aircraft compared to the expected costs of such a strategy. The investment in development of old aircraft was already amortized. The pressure at the time was to generate immediate sales of new aircraft in order to capture market share and drive down the average fixed costs of developing and building the new aircraft. Possible long-run costs of such a policy were discounted at a higher rate than the immediate impact of generating new aircraft sales.

It is also important to recall the specific conditions under which this policy decision was made during the last third part of the 1980s. The country's rate of economic growth had started to slow; the absolute number of orders for new aircraft fell in 1987 for the first time since the beginning of the economic recovery in 1983; and the price differential between new and old aircraft did not justify significant retirement of old aircraft. The major objective of the US manufacturers was to generate immediate sales of new aircraft and to increase market share by accelerating retirement of the previous-generation aircraft.

3.2 The Airlines' Problem

Theory gives us a way to understand the so-called present value effect, which captures the market response to a manufacturer's strategy. This effect corresponds to Coase's idea of the buyer's response to the monopolist's intertemporal pricing strategy.

In our story, the airlines' response to the manufacturers' strategy is crucial for an understanding of the overall market result. In the air transportation industry, aircraft transactions largely represent a bilateral-monopoly arrangement between a manufacturer and a major airline. It is hard to credit that the manufacturers' strategy not be transparent to the airlines—that airlines would fall blindly into the manufacturers' trap. What should the airlines' strategic response be? Should airlines attempt to circumvent efforts by the manufacturer to kill the market for old aircraft, or should they accommodate the manufacturer's strategy? In our story, the airlines effectively colluded with the manufacturers, and responded by placing an unprecedented number of orders for new aircraft at increasing prices. Why?

The airlines' conduct can be interpreted in the context of strategic behavior models. The previous chapter discussed the strategic importance of investments in hub-and-spoke networks. Investment in a hub system, while directly impacting the hub airline's production and cost functions, also strategically affects the competition's position. A partial explanation of the major airlines' move to place such a volume of aircraft orders can be related to strategic investment in overcapacity directed at deterring entry. Credible threats to deter or preempt market entry require actual investment in durable, transaction-specific assets. The major airlines made a significant specific (sunk) investment in hub-and-spoke network systems. Contrary to the contestable markets argument that aircraft are not specific to a route, and are therefore not a sunk cost, in fact aircraft are an *integral part* of a network system. An airline cannot have a route system without the aircraft to operate it. Nor is investment in a complex network system credible without acquisition of the aircraft to operate the system. A network system including the aircraft is specific and requires meaningful sunk costs. The major airlines' strategic move both to create such network systems and to order a significant number of new aircraft represented a credible threat to new entry, and had a direct exclusionary impact on competitors. The major airlines had captured ground and airside limited space by high-frequency aircraft operations.

3.2.1 Raising Rivals' Costs of Acquiring Aircraft

The strategic nature of hub-and-spoke networks has long since been widely recognized. I'd like to focus on a related aspect of strategic behavior that has gained acceptance in economic theory in general, not with particular respect to the airline industry. The group of major (financially strong) airlines embarked on a policy aimed at doing away with the old aircraft in an attempt to raise the costs of rival airlines that specialized in operating such aircraft. Raising rivals' cost (RRC) is a familiar exclusionary strategy in industrial organization as well as in antitrust cases. An example is a celebrated 1985 study by the Department of Justice, which concluded that American Airlines through control over its computerized reservation system raised booking service prices for a group of new entrants (Air Florida, NY Air, and Midway). In this case, there was a direct strategic impact on the rivals' cost, and through a practice implemented at a negligible cost to the incumbent.

The move of certain airlines to affected old aircraft in an attempt to increase rivals' cost falls into a somewhat more complex category of RRC. Adopting such a policy would require strategic investment by the group of airlines that adopted it, and the policy moreover would subsequently be expected to increase costs for all airlines, not just new entrants. Yet the heterogeneous structure of the industry made it likely that the group of airlines that specialized in and depended on older aircraft technology would suffer rather more than the group that specialized in new aircraft technology. A landmark antitrust case that illustrates this strategic behavior is the Pennington case (Williamson, 1968). In this case, it was alleged that capital-intensive coal producers conspired with the labor union to raise wages. This strategy was expected to more severely affect labor-intensive rival producers.

It is instructive to look at the strategic problem for the airlines using a simple formulation of a two-stage game of an oligopolistic setting. We assume for simplicity that airlines can be divided into two groups: one using proportionally more new-generation aircraft and the second proportionally more old-generation aircraft. The first group makes (in stage one) a strategic investment in lobbying for regulation to kill the old aircraft. Such an investment affects both groups' costs in the second period. The standard theoretic solution requires that equilibrium in the second stage will depend upon the strategic investing in the first stage and the impact of a marginal (ex-ante) investment on profit (ex-post).

The first group's strategic move increases the cost of operating old aircraft and the cost associated with acquiring new aircraft for both the first and the second group of airlines. The general analytical characteristics of the equilibrium suggest that such a strategic move has offsetting effects of increasing the first group's cost as well as the rivals' cost, and the result depends on both groups' optimizing responses. The analytical model shows that the profitability of such a strategy for the first group cannot be taken for granted. It depends on the specific formulation and the parameters of the game, since the reaction functions move in opposite directions.

One of the problems in analyzing such strategic games is that their complexity often makes it impossible to ascertain winners and losers, if any. This is particularly evident in making antitrust arguments, because simplified analytical models may shed light on some of the underlying forces but are often partial and tentative, and depend on specific assumptions. Real-life situations, on the other hand, are often too complex and uncertain to provide the degree of analytical specification required for a clear-cut solution. Analytically and intuitively, however, it is clear that for the new-old aircraft strategy to make sense, the cost effect on the rival airlines must be significant in order to compensate for the increased strategic investment and its impact on the major airlines' cost. The difference in production (and cost) between the two groups of airlines (the extent of heterogeneity) is significant in the overall solution.

3.2.2 Industry Heterogeneity

Increased industry heterogeneity was in fact one of the important effects of deregulation and free competition. The gap between the financial position of the strong airlines and the weak ones had widened toward the end of the 1980s. Figure 6 reflects the distribution of operational margins of the major airlines in July 1989.[47] EAL, PAA USA, and TWA experienced negative margins, the remaining airlines positive margins. Heterogeneity had also evolved with respect to fleet composition. As the second generation of aircraft became available, airlines faced a wider choice of aircraft in their fleet composition decisions.

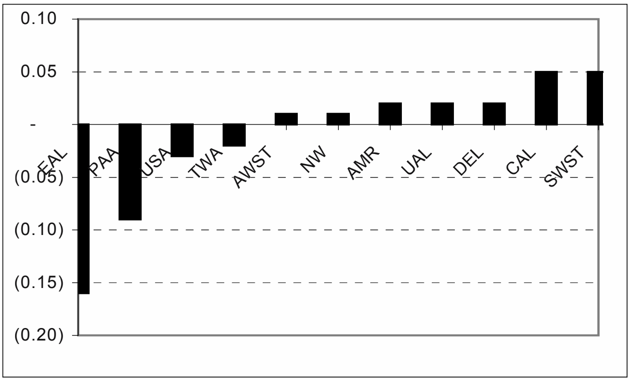

Figure 6. Profit Margins

Figure 7 reflects the distribution of first- and second-generation aircraft across airlines in 1989. The financially stronger hub airlines specialized in newer aircraft technology. American Airlines, United, and Delta, the three largest airlines, which controlled close to 60% of the market, operated more second-generation aircraft than the rest of the airlines, and also were better positioned than other airlines to acquire new aircraft. On the other side of the pole, Pan American, Eastern Airlines, TWA, US Air, and Northwest had the highest proportion of first-generation aircraft (65% and more), so imposing regulation on first-generation airlines would have a disproportionate effect on this group. These airlines were also financially weaker than the other group, which made an accelerated retirement of older aircraft and acquisition of new aircraft very difficult, if possible at all.

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[47] Source: Air Transport Association, six-month period ending June 1990.

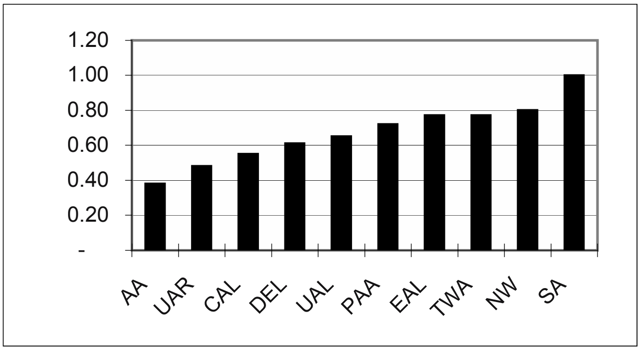

Figure 7. Stage II Aircraft—Ratio by Airline—Year-End 1989[48]

The acquisition of new aircraft required taking on significant amounts of debt in capital markets. The industry's long history of low profitability made the use of public debt problematic. Prior to deregulation, a few of the major airlines had issued public debt in spite of the industry's relatively low profitability. The fact that the industry was regulated helped a few of the major airlines gain low ("speculative") investment grades from Moody's and Standard & Poor's. Shortly after deregulation, almost all major airlines entered the public debt market. They received mostly non-investment-grade ratings of BB+ or lower from S&P. During the second half of the 1980s, things changed somewhat, and the three major airlines (American, United, and Delta) as well as Southwest obtained investment-grade ratings. The other airlines were forced to borrow at high junk bond rates

Such borrowing in the middle and the second half of the 1980s increased the leverage ratios of the second-tier airlines and exposed them to high interest costs. For example, Eastern Airlines, Continental, and TWA raised a significant amount of so called "junk" debt during this period through the then-popular Wall Street underwriter, Drexel, Burnham as part of leveraged buyouts or otherwise. This borrowing largely depleted their borrowing power. One of the junk bond issues of the time was nicknamed the "light bulb indenture," referring to the pledging of all the airline's unencumbered assets (including the light bulbs) as collateral. Borrowing under these conditions further weakened the future borrowing ability of the less stable airlines in the late 1980s, making their prospects for modifying old aircraft or acquiring new ones highly questionable.

Regulation that increases the cost of older-generation aircraft was indeed expected to affect the industry as a whole, although it was supposed to have more of an impact on the least financially strong airlines. American had the lowest percentage of old aircraft, and was the strongest proponent for noise regulation that affected older-generation aircraft. For the weaker airlines, complying with new noise regulation required diversion of needed resources from the creation and extension of

[48] Source: Calculated from data provided in *World Jet Airplane Inventory*, Boeing Commercial Airplane Group, 1990.

hubs and new markets, and for certain airlines actually threatened their ability to survive. These new regulations also directly raised financial barriers for new entrants into the market.

For these major reasons, the financially stronger airlines joined the manufacturers in pushing for new regulation that focused on first-generation aircraft. The regulations included age-related maintenance schedules as well as noise abatement requirements of unprecedented scope. At the same time, the airlines placed a record-breaking number of orders for new aircraft at increasing acquisition prices. Figure 8 shows the changes in the cost per seat-mile spent by the airline industry for aircraft acquisition during the 1980s. The rate of growth in the cost reached its lowest point of over 3% in 1986 but then more than tripled to over 10% in 1989.[49]

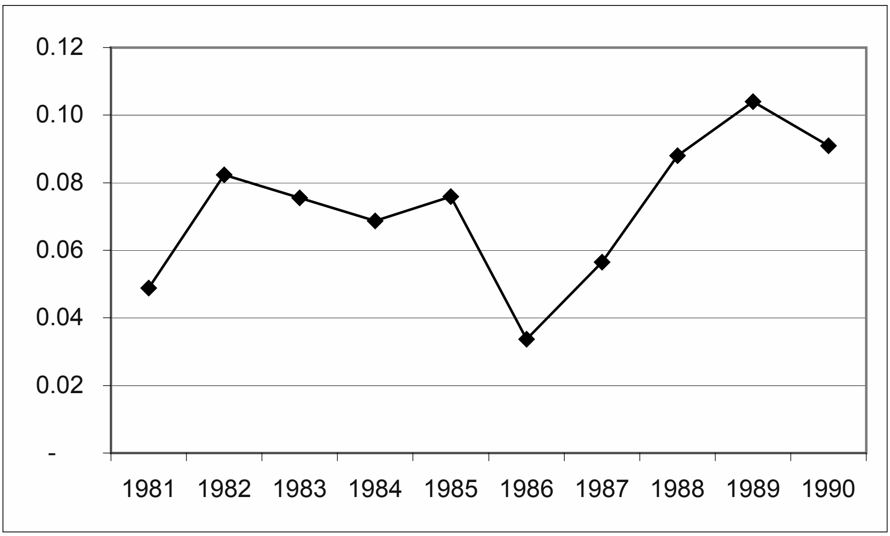

Figure 8. Rate of Change in Aircraft Acquisition Cost

4. ON ESTIMATING DEMAND FOR NEW AIRCRAFT

I have routinely watched the behavior of orders and prices of new aircraft. I was particularly intrigued with the data during the last several years of the 1980s, sensing that a change was afoot, but I could not figure out exactly what. Even today, with a better understanding of what I believe happened, I am still puzzled. What makes an industry's orders book take off in such a manner? A review of a time series of

[49] Calculated from data in *Air Transport World*, December 1999, p. 7.

aircraft orders and deliveries against economic (and/or industry) cycles since the advent of the jet age reveals that new aircraft orders usually increase at the end of an economic cycle. Then actual deliveries reach the market later, when airlines may already be struggling with recession and the aircraft are needed the least.

4.1 New Aircraft Orders

With the advantage of hindsight, we know that new aircraft orders overshoot and are not synchronized with the market cycle. Several reasons have been suggested for this phenomenon. Airlines are too optimistic in their predictions; they traditionally err in predicting recessions; orders follow capacity shortage at the peak of a cycle; capacity adjustments are never smooth; airlines place orders in strategic response to other airlines placing orders; airlines are ego- and prestige-driven and sometimes they just like new toys, and so on. In 1990, we experienced the Gulf War, which provided a standard justification for creating a large surplus capacity of aircraft. The standard explanation became the "Gulf War surprise." In fact, who could blame the industry for not being able to predict the Gulf War?

There may be some truth in explanations of what happened, but they disguise the non-obvious side of the story. In fact, forces other than expected demand drove orders for new aircraft up. The manufacturers took aggressive steps to boost aircraft orders and adopted a policy of undercutting the older aircraft in an attempt to increase the new aircraft user base. The larger airlines joined the manufacturers in an attempt to raise rivals' costs and increase their market share. I was sceptical at the time that either the manufacturers or the airlines would gain long-term profits from such a move. The manufacturers should have known that even if the airlines accommodated their strategy, payback time would arrive—in the workings of the present value effect.

The manufacturers' strategy was transparent to the airlines, which were expected to negotiate lower prices in the current or the next round of aircraft orders. In addition, the manufacturers' commitments to finance a portion of the new aircraft acquisitions made them vulnerable to an airline's default. The manufacturers fueled this order frenzy by providing financing and assuming the risks of airline defaults, all to create demand for their own aircraft.

A growing industry of "operating lessors" participated in this aircraft order spree as well. The two major leasing companies, GPA and ILFC, encouraged by the manufacturers, placed a large number of orders and bought options for new aircraft deliveries, in many cases without identifying a particular end-user. These leasing companies shared some of the airlines' and manufacturers' risk, and provided an additional source of financing in the face of a general shortage of traditional credit sources, but their competition for dominance in the operating lessors' market further increased the number of orders compared to the industry's needs. As the number of orders increased, so did the manufacturers' contingent liabilities and negative exposure with respect to their production and financing offers. It was clear that the manufacturers would have to absorb a major portion of the cost of airlines defaulting on their commitments.

I was also skeptical as to whether the deterring entrance and increasing rivals' costs strategies would eventually benefit the major airlines to an extent that would cover the cost of acquiring and operating the new aircraft. At the end of the day, airline revenues must cover the acquisition cost of aircraft—and the problem is that the overall cost of operating the new aircraft including rent or ownership costs was high. Even a senior official in American Airlines, one of the leaders of this strategy admitted that: "[the] new aircraft don't give very good operating cost economies. New planes are better but don't totally offset the ownership costs."[50]

From the beginning, it was highly questionable whether the industry would be able to generate enough revenues to cover the cost of acquiring and operating the new aircraft, especially since new aircraft make economic sense only with high levels of utilization and load factors—yet demand was falling.

The picture became even more puzzling in 1990. More and more observers were predicting economic slowdown, and there were increased fears of inflation and uncertainty regarding oil prices even before the Gulf War commenced. The industry activity measured in revenue passenger miles for 1988 and 1989 fell. During the last quarter of the 1980s, airlines' costs increased and revenues lagged. The airlines faced a significant reduction in the traditional revenue-generating business travelers, due both to the economic cycle and the exploding popularity of new communications technology in the form of fax and teleconferencing.

Starting in 1988, jet fuel prices increased proportionally more than crude oil prices, disadvantaging the industry; meanwhile, labor negotiations concluded, and increased costs as well. Airlines responded to the diminishing growth rate of demand in 1989 with fare cuts, and revenues fell in 1989. Mergers and leveraged buyouts and takeovers increased the industry's overall interest expense and leverage ratios. The financial markets were reluctant to lend to finance aviation transactions in the late 1980s, due to deteriorating balance sheets, even before the beginning of the Gulf crisis. The Far East was the only market that was still growing strongly and could mitigate to some extent the impact of the approaching economic downturn on demand for new aircraft.

It was clear to many observers that placing such a large number of aircraft orders was out of line, not to say extremely risky, since there was no need for such capacity, nor was it clear how the industry could finance and pay back such an expense. Even later in 1990, after the Gulf crisis erupted, manufacturers continued their aggressive marketing efforts, and airlines responded by placing orders for even more new aircraft backed by manufacturers' financing commitments.[51]

4.2 Market Outlook

One of the rituals of the airlines industry is publication of the manufacturers' market outlook at the beginning of every year. The early 1990 forecasts attracted much

[50] Donald J. Carty, quoted *in Commercial Aviation Report* (1990, December, p. 10).

[51] For example, Boeing and P&W participated as lenders to UAL (*Commercial Aviation Report*, October 15, 1990, p. 3). Boeing provided a "backstop" commitment to finance Continental's acquisition of 757s (*Commercial Aviation Report*, November 1, 1990, p. 8).

attention. Boeing's was the most optimistic forecast, predicting that world airline market activity would grow at 5.9% per year throughout the decade (Airbus predicted 5.6% until 1998). Even with respect to the US market—where recessionary pressures had started to emerge along with concerns that market maturity might alter historical growth rates— Boeing predicted a 5.2% growth rate per year (Airbus predicted 4%). The forecasted growth rates were translated into expected aircraft orders on the basis of some obscure combination of a simple regression analysis not always disclosed and not obvious judgment.

Generally, it had been assumed that the industry's activity (measured in RPM) would grow at two to two and a half times the economic growth rate. This coefficient was based on the unprecedented economic boom of the 1980s and the accelerated post-deregulation industry growth

It struck me as odd that Boeing predicted that by year-end 2005, the industry would need an additional 10,000 new aircraft at a total value of $626 billion. I did not see how the market could absorb so many aircraft, or how the industry could finance their acquisition while generating enough revenue to repay the debt and provide reasonable return to shareholders. I was not alone in pointing out this anomaly. Almost everyone saw it, yet orders for new aircraft kept coming. By the end of 1990, Boeing's orders for new aircraft broke the record, and reached their highest point.

I eagerly waited to review the Boeing Current Market Outlook published in February 1991, more than six months after the Gulf crisis started and more than a month after Eastern Airlines, the first major casualty of the industry crisis, was shut down. The airlines recognized that they faced a major crisis. The editorial section of the October 1990 *Air Transport World* opened with the following:

> There is a chill in the air. A traffic downturn for the airlines, a drop in orders for manufacturers and an overall business recession seem to be the likely result of Iraq's attempt to grab the riches of its neighbors. For some struggling US carriers, this development may be the final straw (*Air Transport World,* October, 1990, p. 2).

A detailed article in the same issue underlined the problem of increased capacity. A review of industry statistics for the first seven months of 1990 indicated that capacity had grown more than traffic. This trend was stronger in the domestic market, where available seat miles (ASM) rose 6.3%, twice as fast as traffic (RPM).

To my surprise, Boeing largely ignored the Gulf War's impact on the industry as well as the deteriorating general economic and industry conditions. When I read the February 1991 Market Outlook, I was already fully involved in liquidating Eastern Airlines' assets. In a complex (and unhappy) logistical operation of a magnitude that was never seen before, we flew a large number of aircraft to be parked and stored in the Mojave Desert. Quickly thereafter, this became almost a routine practice, as more aircraft were mothballed in the desert. Boeing, however, suggested in its forecast that the industry would bounce back quickly. Air travel is projected to return to its position on the demand curve, "which has usually been the outcome when unexpected disruptions have occurred" Boeing (1991, p. 3).

This published statement referred to a chart showing two standard textbook demand curves, one to the left of the other, with an arbitrary equilibrium point P1 indicated on the right curve. It stated that the curve "shifted [left] due to income." A new equilibrium point P2 representing a higher level of airfares and a lower number of passengers was identified on the second demand curve, with the note: "Near-term influences could cause a move from P1 toward P2. Upon resolution of problems, recovery back to P1 should occur" Boeing (1991, p. iii).

Boeing decided to ignore the nature of the crisis, suggesting that the industry focus on its average long-term growth trend *and continue ordering new aircraft*. Boeing also did not change its last year's predictions and claimed that:

> The substantial growth in forecast incremental travel volume combined with the replacement of retired airplanes provides a forecast market for the manufacturers of $617 billion (1991 dollars). This is approximately the same amount as forecast in last year's Current Market Outlook (Boeing, 1991, p. iii).

Not only did Boeing not change its general market outlook in 1991, relative to the previous year, but in fact it also locked into its overly optimistic predictions, thus encouraging the airlines to place more aircraft orders.

Most of my time during 1991 was spent repossessing aircraft due to airline default or bankruptcy, or otherwise negotiating and restructuring aircraft loan and lease agreements. It continued this way for the next three years as well. The airlines I dealt with were mainly financially weak ones (Pan Am, Eastern, TWA, Midway, Continental, and Braniff). By 1991, it had become apparent that the crisis had accumulated more steam and was starting to take its toll on the financially strong airlines as well.

At the beginning of 1991, US airlines had an estimated total of $165.2 billion in aircraft on order: $45 billion by United, $23 billion by American, $26 billion by Delta, and $21 billion by Northwest. (*Commercial Aviation Report*, 1991). Concerns mounted as to how this amount could be financed and how the debt could be paid back. There were rumors for several months that American Airlines planned to significantly cut its capital spending. In a sequence of announcements and speeches, starting September 1991, Robert Crandall, American's CEO, confirmed the airline's intention to reduce its capital and aircraft spending. In November, it became public that American was planning to trim up to $4 billion over the next five years. During the inauguration of American's new Seattle-Tokyo service, "Crandall dropped a bigger bomb. The company was negotiating to defer aircraft deliveries." The CEO said American had presented Boeing with a proposed rescheduling of aircraft deliveries. According to an industry publication distributed in November 1991, US Department of Transportation Secretary Sam Skinner had: "growing concern about the ability of the US airline industry to pay for the billions of dollars' worth of aircraft on order." (*Commercial Aviation Report*, 1991, p. 1). According to the same publication, Skinner discussed this issue with Boeing's chairman in September.

In March 1992, Boeing's Current Market Outlook was published. Again, the document largely ignored the industry crisis, suggesting instead a focus on the long-run industry growth trend as it had been forecasted on the basis of a simple econometric model and subjective judgments regarding explanatory variables. On the first page of the document, Boeing stated, "there are no cycles in the forecast." The word "cycle" was footnoted as follows:

> Cycles, by definition, mean regularly sequenced phenomena. The Boeing view is that unique circumstances caused the major adverse change in the historical market and that such events are random and, therefore, not predictable (e.g., energy crises, wars). Even economic growth is hardly cyclical. Good monetary and fiscal policies can prevent major economic disruptions. Only two major world recessions have occurred in the jet era, and they were begun by energy crisis (Boeing, 1992, p. 1.1).

The product delivery section almost repeated the language of the previous year:

> The substantial growth in forecast incremental travel volume combined with the replacement of retired airplanes provides a forecast market for the manufacturers of $857 billion (1992 dollars) through 2010. This is nearly equivalent to the forecast in last year's Current Market Outlook (Boeing, 1992, p. 1. 8).

4.3 *Aircraft Deliveries*

The Gulf war, recession, and other market changes brought about a major crisis in the aviation industry during the early 1990s. A cyclical economic downturn was not unexpected after a long expansionary trend that had lasted almost eight years, but a dramatic (although relatively short) oil shock was a surprise. Accelerated by this shock and aggravated by a great overcapacity of aircraft, the recession had a devastating impact on the industry. The impact of the recession was particularly destructive because so many new aircraft ended up being delivered to an industry that needed them not at all.

In 1989, oil prices averaged $17.37 per barrel. Affected by a cold winter, prices averaged $19 per barrel in the first quarter of 1990, before settling back to about $15 in the second quarter. In August, Iraq invaded Kuwait. The subsequent embargo and fear of war sent oil prices to over $40 a barrel. By year-end, prices had dropped back to $25 (Boeing, 1992).

The supply and demand shocks affecting the air travel market, together with the overall recession and the industry's overcapacity, brought about far-reaching changes in the industry's structure. In the fall of 1990 it was already clear that:

> Things are likely to get worse before they get better, because with 500 new jet transports scheduled to be delivered in 1990-91—80% of them narrowbodies for domestic service—capacity growth is likely to accelerate for the remainder of this year and next, unless some airlines begin retiring older jets...but no one wants to be the first to cut capacity, because that could translate into loss of market share (*Air Transport World,* October 1990, p. 62).

The unfolding crisis became more severe and lasted longer than even the most pessimistic observers would have predicted. In February 1992, Bob Crandall claimed:

> The airline business lost $5 billion last year and if [it doesn't] stop losing money then there won't be an airline business in the future. The airline business is going broke, and better times are not near (A*ir Transport World,* February 1992, p. 62).

In some respects, the major airlines reaped even more than they had hoped for in their wildest strategic dreams. The cost, however, was very high. By the end of 1992, before the new aircraft age and noise regulation had a chance to impact the market, Eastern Airlines, Pan American, and Midway went out of business, and

TWA, Continental, and America West filed for bankruptcy protection. The wave of bankruptcies and airline shutdowns spread all over the world, but the deregulated US industry was the hardest hit. The major airlines acquired the failing airlines' assets, gaining additional market share and becoming even larger and more powerful. After the demise of Eastern, Delta became the dominant carrier in the Atlanta hub. It also acquired Pan Am's international routes to become a major player on the Atlantic routes. American acquired Eastern's and TWA's international routes, and expanded to capture a dominant position in the Latin American market.

During 1991 and 1992, a record-breaking number of new aircraft were delivered into an otherwise devastated industry. More than 10% of the industry's aircraft fleet was estimated to be grounded; aircraft utilization levels had been reduced; and West coast and Midwest deserts quickly became aircraft storage places or graveyards. First-generation aircraft were disassembled or "cannibalized" for parts, as spare part values often exceeded the market value of a complete aircraft. As new aircraft utilization and load factors fell, orders for additional aircraft were cancelled or deferred. In some cases new ("white tail") aircraft simply rolled off the manufacturing line and into storage in the desert.

Figure 9 plots the number of new aircraft deliveries to the world airlines market. It shows very clearly the significant increase in aircraft deliveries during the period 1990-1993.[52]

The unprecedented number of aircraft orders of the last quarter of the 1980s materialized into an unprecedented number of deliveries during the first quarter of the 1990s. And then 1991 turned out to be one of the worst years in aviation history, as the growth in world airline traffic became negative (down 2.3%) for the first time since the advent of the jet age. Even during the two previous major recessions, in 1973–1975 and 1979–1982, average growth in world traffic had been positive.[53] The industry total losses during 1991–1993 wiped out the cumulative profits of the industry since the beginning of the jet age.

[52] Source: Boeing, *World Jet Airplane Inventory*, 1994.

[53] 4.1% and 1.9%, respectively (*Boeing Current Market Outlook*, 1992).

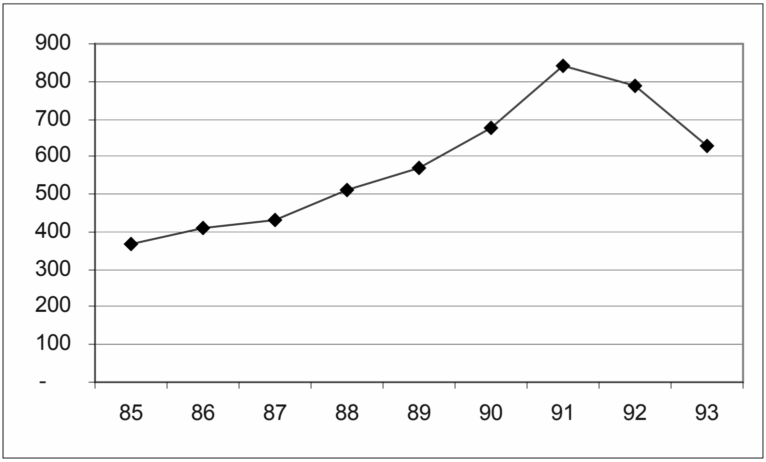

Figure 9. New Aircraft Deliveries 1985 –1993

Figure 10 shows the yearly losses of the world industry during this period.[54] The year 1991 was one of the worst years in world airline performance—as well as the year the number of new aircraft deliveries broke all previous records. Close to 850 new aircraft were delivered to the industry during 1991 and close to 800 in 1992. Already plagued with significant overcapacity and fighting for survival, the industry had to start paying the bills for these new aircraft.

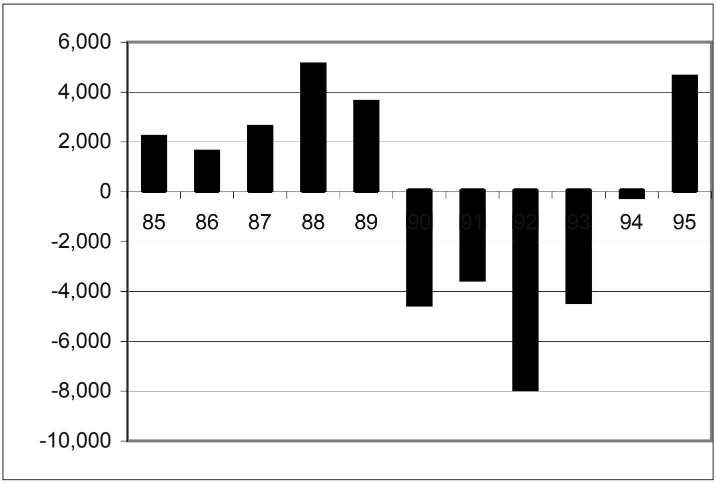

Figure 10. World Airlines Net Profits 1985–1995

[54] Source: ICAO data 1996.

There were many losers in this round of the game. Financially weak airlines filed for bankruptcy; Pan Am, Eastern, and Midway went out of business; TWA, Continental, and America West operated under bankruptcy protection. The manufacturers could not deliver all the ordered or optioned aircraft. Orders and deliveries were cancelled, delayed, or restructured, and the manufacturers absorbed significant losses. GPA, the largest operating lessor, became practically insolvent and had to be bailed out by General Electric. Operating lessors of older aircraft filed for bankruptcy or otherwise exited the market. The falling values of old aircraft caused the collateral value of bank and public debt to collapse. Private and institutional investors who had invested in bonds backed by aircraft lost significant portions of their investment.

The diminished used aircraft market values caused market equity that airlines had accumulated to evaporate. The only winners may have been aviation lawyers, as defaults, repossessions, foreclosure sales, bankruptcies, and financial restructuring soared. The major airlines absorbed a significant portion of the defunct airlines' assets, thereby increasing their market share, but at a very high price. Ironically, the majors ended up absorbing the bulk of the noise and safety regulation costs they had hoped to impose on their rivals as much of the competition disappeared from the market.

5. RECOVERY

The combination of manufacturers' competition for increasing user base in the aircraft market and the airlines' competition for market share in the air travel market pushed the industry to a point where standard economic reasoning was ignored or else made not applicable. The manufacturers pressed to increase deliveries in an attempt to reduce average fixed production costs. With the expected falling rates of market growth, killing the old aircraft was adopted as a strategy that would encourage demand for new aircraft.

The airlines themselves faced a somewhat similar problem in the air travel market. The high fixed costs of the complex and expensive network systems they had built required increased aircraft operations and market share. Overcapacity at hubs captured limited groundside and airside space, foreclosed rivals' entry, and deterred potential new entry. Killing the old aircraft was for the airlines a strategy aimed at raising rivals' costs.

In the late 1990s, the manufacturers and the airlines were locked into what became a self-destructive strategy, induced by their respective search for increasing market share. The number of aircraft orders surged, which made the impact of the imminent economic downturn even more severe. The unexpected Gulf War and domestic recession, coupled with an unprecedented number of aircraft deliveries during the early 1990s, forced the industry into the longest and most severe depression ever. Ironically, the surviving older aircraft that had not been permanently retired returned to haunt the big airlines and the manufacturers in the next round.

5.1 The Revenge of the Old Aircraft

Oil prices stabilized quite quickly after the Gulf War. In fact, their average level during the 1990s was to become even lower than in the 1980s. The old aircraft maintained their operational attractiveness. The events of the early 1990s did not change the basic situation: The relative savings offered by new aircraft technology could not justify their acquisition cost. On top of this, in the early 1990s, the price of older aircraft plummeted.

The 727 were the most affected aircraft. An early 1980 model (the youngest in the old aircraft group) was valued at the $12 million level in the late 1980s. Six such aircraft were sold in an auction by the bankrupt Pan Am for just over $3 million each, in the early 1990s. An older 727-200 advanced aircraft (manufactured during the middle of the 1970s) was sold for $6 million a unit during the late 1980s and for just over $1 million in the early 1990s.

The DC9 was perhaps the second-most affected aircraft. The demise of Eastern and Midway Airlines put a relative high number of DC9 aircraft on the market. Retirement of DC9 fleets by Delta, Turkish Airlines, Alitalia, and others further increased availability and pushed prices down. An average DC9 that had been valued at around $6 million in the late 1980s went for under $1 million in 1992 and 1993. To put this into perspective, one must appreciate that an airline considering acquiring a new fully refurbished DC9 or 727-200 aircraft was expected to pay up to $3 million per aircraft ($4 million for a 737-200). The competing new 737-300/400 aircraft were valued at an average $27 million. At one point in 1992, I was involved in negotiating a possible transaction with a Far Eastern airline that was considering acquiring a fleet of 30 DC9 aircraft for about the same price of *one* new 737-400. The combination of low fuel prices, low acquisition cost, and abundant supply of spare engines and parts made the older aircraft more attractive than ever. The acquisition cost of the old aircraft, even including the cost of compliance with the age-related maintenance and noise regulation that had become effective in the 1990s, was still lower than their late 1980s value. And then oil prices stabilized at a lower level once again.

A large number of old aircraft were acquired for operation during the early 1990s in at least two high-profile cases. The first case was Northwest, which decided to expand its short-haul routes using DC9 aircraft. The second was ValueJet. Northwest adopted a different fleet acquisition policy from the policy of the big three major airlines. It decided to take advantage of the depressed market for old aircraft and acquire a large number of DC9 aircraft. Even later in 1996, when general market conditions had improved quite dramatically, Northwest decided to defer an order for A330 aircraft and acquire DC10s instead (*Air Transport World*, August 1996, p. 46). According to Michael Levin, EVP of Northwest, the airline decided to base its aircraft acquisition decision on the standard business criteria of return on capital. Therefore, the fleet was expanded with old aircraft.

Table 3 indicates statistics regarding aircraft operation in 1994.[55] The first row shows the average operational statistics of the DC9 aircraft acquired by Northwest,

[55] Source: *Aviation & Aerospace Almanac*, McGraw Hill, 1996.

and the other statistics reflect industry averages. It is apparent from the Table that Northwest's operating costs per seat mile for DC9 aircraft were significantly lower than the respective industry average operating costs for DC9s. The F100, a newer aircraft with a similar operational profile, was more expensive to operate. 737-300s and 737-500s were less expensive to operate, but required significantly higher utilization and load factors and ranges—and a new 737 aircraft at the time cost almost ten times more than a DC9.

Table 3. Selected Aircraft Operating Costs 1994

Aircraft	Flight Hours	Av. Seats Flight	Av. Stage Length (miles)	Operating Cost ASM (cents)
DC9-30 (NWA)	6.6	100	498	4.37
DC9-30	6.5	100	423	5.32
F100	6.7	97	466	5.58
737-500	8.5	111	570	4.12
737-300	8.7	130	572	4.19

ValueJet, like Northwest, decided to use a DC9 fleet. According to its Vice-Chairman:

> If the company had opted for new aircraft, the depreciation and rental category unit cost would have been four to five times the ownership cost of used aircraft. One could argue that ValueJet would have the benefit of the lower fuel burn and maintenance costs to offset the higher ownership. However, airlines feel compelled to schedule high-cost aircraft for maximum utilization to lower their unit cost of ownership. This is an appropriate tactic if traffic warrants (Gallagher, 1995, p. 37).

Table 4 shows a comparison of domestic cost (in cents) per available seat mile (ASM) in 1994 according to ValueJet Gallagher (1995). It should be obvious from the Table that the increased fuel and maintenance costs are offset by the lower aircraft acquisition cost. It is noteworthy that ValueJet acquired most of its aircraft at the lowest point in the market for DC9 aircraft.

Table 4. Selected Airlines Operating Costs

	Delta	USAir	Southwest	Industry	ValueJet
Labor	3.90	4.90	2.66	3.66	1.60
Fuel	1.05	1.04	0.98	1.05	1.47
Dep & Rent	1.41	1.70	1.02	1.43	0.26
Maintenance	0.40	0.63	0.63	0.45	0.88
Other	2.99	3.25	1.93	2.74	2.59
Total Exp.	9.75	11.52	7.22	9.33	6.80

5.2 Third Generation

During the second half of the 1990s, the industry embarked on a new aircraft acquisition cycle. New aircraft technology had became available as the Boeing 777 joined the widebody long-range aircraft category, and a family of new-generation Boeing 737s (600, 700, 800, 900) and a smaller 717 aircraft were introduced into the shorter-range (mostly hub aircraft) family, as well as a higher-capacity 757-300. Airbus expanded its production into the Boeing dominant long-range "jumbo" market with its A340. The smaller narrowbody Airbus A320/321 version accumulated significant market share and conquered previously US captured markets, and the new and smaller Airbus A319 and A318 were offered in competition with the B737/B717.

The new aircraft in general have more advanced cockpits, airframes, and engines, and are more fuel-efficient. The new technology, however, has in most cases translated into only a relatively small increment of operational economic advantages over the previous generation aircraft at the traditional high price level of new aircraft offered for sale during the second half of the 1990s. Much as was the case for the second-generation aircraft, the third generation—although it represents an impressive technological advance—did not deliver an economic knockout punch to the second-generation aircraft. For the traveling passenger and the airlines, the sometimes increased speed, more advanced wing design, and the more advanced avionics and controls, which are expensive to develop, are typically not much apparent, so the manufacturers could not price the new aircraft at much more than a respective previous-generation piece of equipment. And in fact, list prices of new-generation aircraft during the late 1990s in many cases were similar to or even lower than comparable previous-generation aircraft delivered at about the same time.

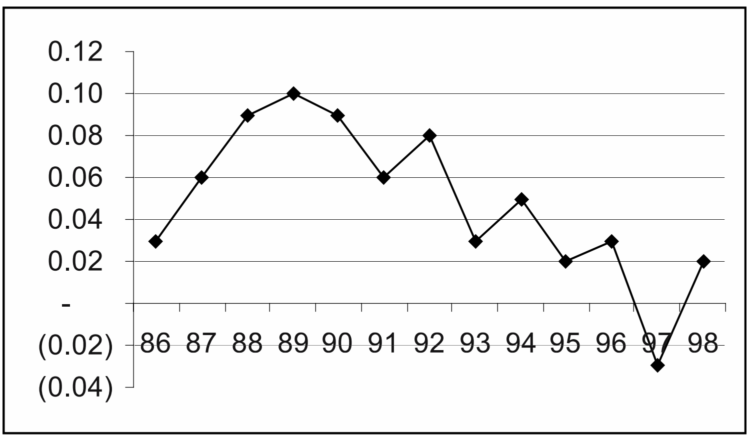

Figure 11. US Airlines Aircraft Cost Index 1986-1988

Figure 11 reflects the behavior of average aircraft cost (rate of change normalized per seat) between the years 1986 and 1998.[56] During the later 1990s and in spite of the increase in orders for new aircraft, cost growth rates were

[56] Source: Air Transport Association.

substantially lower than during the late 1980s (and even negative in 1997). This is an important phenomenon; while during the late 1980s increased aircraft demand and orders occurred together with increased aircraft cost, in the late 1990s demand and orders occurred together with a reduction in cost. A major factor in this trend is the increased competition between Boeing and Airbus over market share.

It is important to note that while the takeover of MDC by Boeing in the middle 1990s resulted in the creation of a duopoly market structure (Boeing–Airbus), competition between manufacturers became stronger than ever before, and the combined post-merger Boeing seems to have lost its clear market dominance. One reason is that during the 1990s Airbus expanded its product line so that it could offer an aircraft to compete against Boeing in every aircraft category (except for the 747-400 where Boeing still had a monopoly). Until the early 1990s, prior to the Boeing and MDC merger, Boeing had been the only manufacturer to offer aircraft in every category. With the introduction of the 319, 318, 320, 321, 330, and 340 aircraft, airlines could in most cases select between competing Boeing and Airbus model aircraft.

The competition over market share by the two manufacturers pushed new aircraft prices and airline costs of acquisition down for the first time in the jet age. In these new circumstances, the price of old first-generation (mostly narrowbody) aircraft was very low and therefore they still maintained their economic attractiveness for certain airlines. Increased industry consolidation and relatively high oil prices in the early 2000s, however, accelerated their retirement. The relatively lower acquisition costs of new-generation aircraft and the increased regulatory burden for older aircraft made newer models–for the first time since deregulation–more attractive for startup airlines as well.[57]

It is no surprise that additional new regulatory efforts focusing on aircraft age, noise, and other negative environmental damages have developed, with an even wider target: killing the first- *and* second-generation aircraft that continued to exhibit very strong market resilience.[58]

[57] ValueJet (Airtran) and JetBlue reflect two new aircraft entry models. ValueJet started up with low-cost DC9s, which significantly reduced its entry cost. Due to the negative post-accident public perception of its old fleet, after gaining a large enough market share that could justify expensive new aircraft and obtaining an attractive deal from Boeing, it gradually moved to operate factory-new Boeing 717 aircraft. Equipped with a significant level of working capital provided by investors to cover the (mostly sunk) cost necessary to capture a break-even market share and obtaining an attractive deal from Airbus, JetBlue started up with factory-new aircraft. These issues are discussed further in Chapter 8.

[58] Noise regulation is discussed in Chapter 5. The September 11th events retarded stage IV regulation efforts somewhat.

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