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Strength and Weaknesses of NPV Analysis and its Application to Aircraft Value Modeling

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by

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This thesis was prepared under the direction of the candidate's thesis committee chair, Dr. Bijan Vasigh, Department of Business Administration, and has been approved by the members of his thesis committee. It was submitted to the Department of Business Administration and was accepted in partial fulfillment of the requirements for the degree of

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ABSTRACT

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The purpose of this study is to analyze the Net Present Value (NPV) technique as a mean to forecast aircraft values and the analysis of aircraft value forecasting accuracy. The main part of the examination is the evaluation of the actual quality of aircraft appraisals. The appraisal evaluation is based on historical forecast accuracy determinations and on a comparison of 1998 aircraft value forecasts. The discussion of a survey conducted by the author in 1998, will reveal the disunity among the appraisers. The survey data was provided generously by the appraisers most recognized in the industry. A sensitivity analysis exhibits how strongly the NPV technique, which is widely used in order to determine aircraft values, is influenced by certain input variables.

Furthermore, in this paper the importance of aircraft value forecasting and factors determining aircraft values will be discussed. Different forecasting techniques, currently used in the appraisal industry, will be explained and aircraft value forecasting results of Credit Lyonnais/PK Airfinance (CL/PK) and Avitas will be analyzed in regard to their accuracy. The main findings were that forecast accuracy is poor for most aircraft, a high disunity among appraisers regarding current market values and finally that NPV results can differ significantly if assumptions in a model are changed slightly. In addition, possible suggestions on how to improve current models will be explained in the conclusion.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

1.1 Introduction to the research topic

Evaluating an aircraft's value and forecasting it's future value is an extremely complex process. The difficulties involved in assessing aircraft values are generally underestimated. The assumption that aircraft values depreciate continuously from year to year is incorrect. In general, we associate lower values with the increased age of a product. A consumer product's value is expected to decrease because of wear, the competition from advanced or more fashionable products, and the expiration of warranties. Values of industrial products reflect the Net Present Value (NPV) of the revenue-generating capacity over the remaining economic life. The economic life ends when the operating costs exceed the revenue-generating capacity. Another crucial element determining the value of a product is the relationship between the supply and demand for that product. Since most products have relatively short lead times compared to an aircraft, imbalances of supply and demand are counterbalanced quickly in general. Changes of output in polypolistic markets with a multitude of manufactures, which exists for most of today's products, are achievable much faster than in the oligopolistic aircraft manufacturing industry.

Due to the lead-times of at least 9 to 18 months and inflexible production rates, there exists a continuous imbalance between demand and supply of aircraft. Since air-traffic growth is inconsistent, the result is either an over-capacity or under-capacity of aircraft available in the market. Over-capacity results in decreasing aircraft values while higher demand results in increasing aircraft values. To summarize, there are two main factors determining an aircraft's value. The first factor is the aircraft's revenue generating capacity, and the second is the imbalance of demand and supply for aircraft which is determined by the state of the airline industry cycle.

Because a multitude of experience and data resources are required to forecast aircraft values, some aviation consultants have specialized in this area. Examples of appraisers are Avmark, Avitas, and Airclaims. Avmark publishes its Transport Aircraft Value forecast (TAV) annually while Avitas' Blue Book is published biannually. These companies provide information about current market values (CMVs) and future values for all commercial jet aircraft.

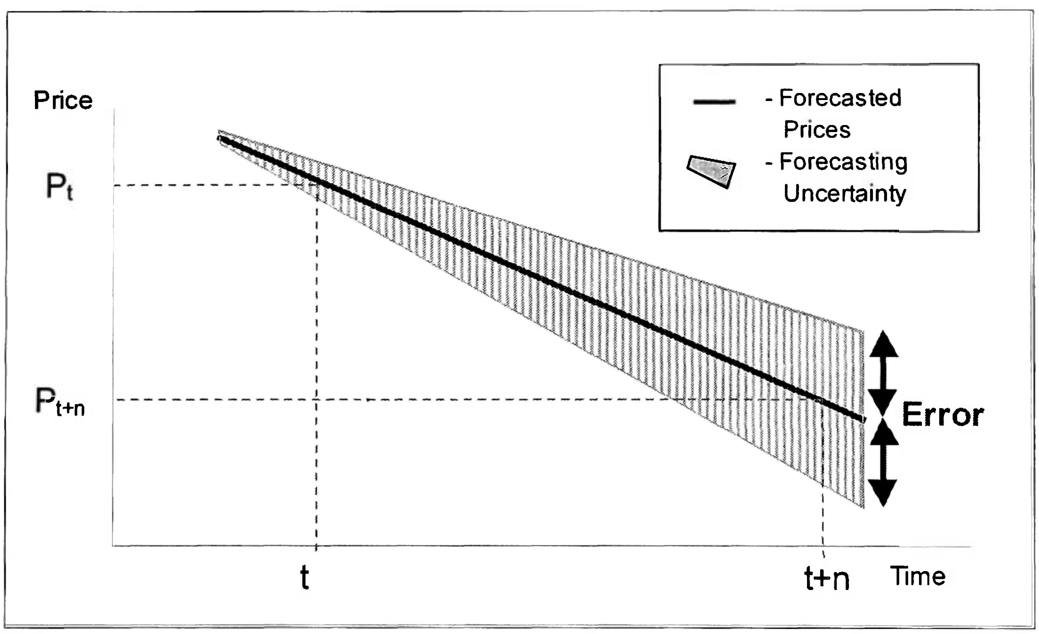


Figure 1. Forecasting Errors Increase Over Time.

The data are sorted by aircraft type and year of manufacture. In addition, the appraisers offer individual aircraft evaluations. Since the quality of an appraisal is very important for customers such as financial institutions, who base their investment decisions on the forecasted values, accuracy must be quantified. Figure 1 shows the general trend of decreasing forecast accuracy over time. Research needs to be conducted to find the forecast accuracy of models that are used by different appraisers.

1.2 Problem definition

The aviation industry and the financial world are recognizing the importance of future aircraft values. Commercial aircraft with price tags between $30 and $150 million are comparable to industrial plants, which create revenue. Unlike a plant, an aircraft has a very high mobility and can be sold throughout the world. As a result of mobility and a consistent trading currency, the U.S. dollar, aircraft are traded in one global market place.

Dealing with a single market, it is very difficult to determine one single price for a specific used aircraft type. Even aircraft built at the same time with similar technical configurations that are equivalent in maintenance and wear & tear conditions are often traded at considerably different prices. How is this possible in a free market where the price is regulated by demand and supply?

Aircraft deals are relatively infrequent compared to other products and prices are not quoted publicly. Therefore, there exists a lack of market transparency and trading prices for similar equipment (Figure 2). In most cases even the prices for new equipment is inconsistent and deviates from the manufacturer's list prices.

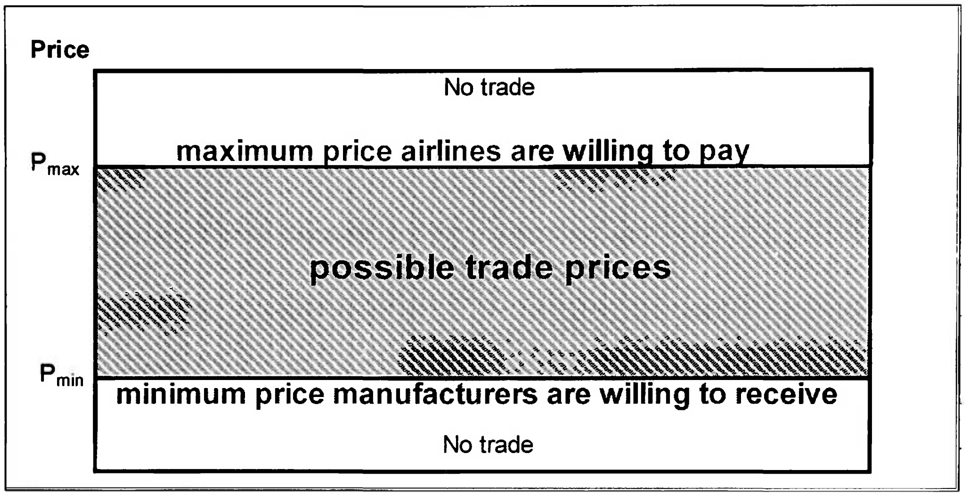


Figure 2. Price Range Versus One Equilibrium Price.

Today as Boeing and Airbus are engaged in a major market-share combat, customers are offered new aircraft at high discounts. For instance, customers like the leading leasing companies such as International Lease Finance Cooperation (ILFC) or GE Capital Aviation Service (GECAS), generally ordering large volumes, are taking advantage of their strong bargaining position. The discounts negotiable for new aircraft normally depend on the economic cycle, but despite high demand, the desperate fight for market-share between Boeing and Airbus during 1996 and 1997 resulted in low profit margins for both manufacturers. The situation for the manufacturers became worse during the Asian economic crises when orders dropped and carrier canceled firm orders.

One additional reason for varying aircraft prices is the high degree of customization. Especially the value of the buyer-furnished equipment (BFE) such as seats, in-flight entertainment, galleys or toilets varies significantly. Consequently, the price for the same aircraft type depends on a customer's ordered configuration (Holloway, 1992).

The combination of varying new prices, customized configurations, and different technical conditions causes difficulties in the determining CMVs of used aircraft. Even more difficult is the task of predicting an aircraft's future value.

Further inconsistency is caused by environmental regulations, which may affect the economic life of older aircraft. For example, the operation of Stage II aircraft will be prohibited in Europe after December 31, 1999 and in the USA after April 1, 2002. To avoid their phase out, many of these aircraft will undergo costly hushkitting or re-engining programs. How to approach the valuation of these aircraft raises new headaches in the appraisal industry. The main source for uncertainty in aircraft value predictions is the economic condition of the airline industry. Predicting cycles in the cyclical airline industry is a very difficult task. Despite continuous industry growth, many specialists consider 1998 as the peak of the current boom. The probability of a downturn is a topic that is currently being discussed at length industry wide (O'Toole, 1999).

In summary there exist two very important factors creating difficulties in the determination of current and future values of used commercial aircraft:

- A lack of information regarding aircraft transaction prices.
- The differences in specifications and maintenance status of the aircraft mean that one price observation is not translatable to another aircraft.
- Uncertainty about future demand for aircraft due to the cyclicality of the airline industry

1.3 Terminology

When discussing aircraft values, it is important to use the correct terminology in order to avoid confusion between the most likely trading value and the theoretical base value. To prevent confusion it is essential to define the main types of values referred to throughout this paper.

<u>Bbase value:</u>

The first step in an aircraft or an aircraft type evaluation is to determine the base value. The main assumption in this process is that demand and supply for aircraft are in balance. Furthermore, it is assumed that the aircraft is in half-life maintenance condition, in standard configuration, in standard specification, and complies with all regulations required by aviation authorities. An aircraft is in half-life condition if it is between two D-checks. The revenue generating capacity is calculated based on anticipated average direct operating cost (DOC), average utilization, average stage length, standard yields and service life. The NPV of all expected future cash flows represents the base value of an aircraft (Hallerstrom, 1998).

When addressing the problematic nature of aircraft values, it is crucial to be consistent with the terms used. The Base Value, according to the definition of the International Society of Transport Aircraft Trading (ISTAT) is the aircraft's inherent long-term value in a market where supply and demand are relatively in balance (ISTAT, 1997). This definition also assumes that an aircraft is sold in an open, stable, unrestricted market in the absence any abnormal conditions, such as artificially limited marketing time.

Economic value:

The concept of economic value relates to an asset's ability to generate positive after tax cash flows. An investor anticipates that expected future cash flows and the resale or salvage value of the asset itself will provide compensation for the present value given up. Not only the future cash flow but especially a representative discount rate needs to be identified. The sum of the discounted positive or negative future cash flows resulting from an investment represent the value of the underlying asset. Furthermore, the discount rate takes in consideration the risk involved in an investment. In other words, the probability that the expected cash flows will actually be received. Risk adjusted discount rates add a premium to offset the investor for the extra risk of holding the asset. The economic value is not absolute but represents the relative risk assessment of an investor's expectation (Helfert, 1991).

Economic value is a trade-off concept because a buyer's willingness to pay depends on the assets expected cash flow generating potential. The Economic Value concept needs to be considered as the core analysis technique for business investments, operating and financing decisions.

Trading value:

Throughout this paper, the most likely trading values will be refereed to as current and future market values. The price for an asset paid in an actual transaction is referred to as market value or fair market value. Transactions take place in organized markets such as the New York Stock Exchange, or between private parties. One condition for the market value is that the parties involved are free of duress. In market-oriented economies, the market value is determined by the interaction of supply and demand. Expressed graphically, the intersection of a supply curve and demand curve represent the value marginally agreed to by a satisfied seller and buyer (Moger, 1990). Buyers' maximum willingness to pay and the minimum prices at which sellers are willing to trade is expressed by the demand and supply curves respectively.

In an equilibrium market the expected rate of return on the asset is equal to the investors' marginal required rate of return. Due to changing conditions, expectations in regard to the asset's future cash flow generating capacity alter, and as a result the market shifts into disequilibrium. Changing conditions are reflected in the up or down movement of market price until a new equilibrium price is established. Sources for changing conditions can be of different nature. Changing preferences or perceptions of the parties involved as well as psychological climate, economic variations, industry developments political conditions, etc. can cause the occurrence of market disequilibriums.

For frequently-traded assets such as stocks and bonds the market value is well known instantly, even though millions of transactions result in daily and hourly variations. Unless a transaction takes place, market values assigned to infrequently traded assets, such as aircraft, are estimates. Estimating realistic transaction values for infrequently traded assets can become an extremely difficult task (Helfert, 1991). The qualities of market value estimates depend on the validity of assumptions in regard to individual preferences and economic conditions.

Finding the market value or the most likely trading value for an aircraft, the base value, which neglects the imbalance of supply and demand, needs to be adjusted for the current market condition. Only then does the value reflect what a buyer would be willing to pay for that aircraft at that point in time. In order to forecast aircraft values, the base value is calculated for each year of the forecast horizon. Subsequently, the base value is adjusted for technology advancement and environmental regulations, which could affect the service life of a specific aircraft type. In order to forecast the most likely trading value or market value, each forecasted base value is adjusted for the predicted demand imbalance.

The CMV, according to ISTAT, is the price the aircraft would most likely sell for in today's market, also called fair market value. The CMV depends primarily on the stage in the economic cycle and is adjusted for the actual technical status and the maintenance condition of the aircraft.

Book Value:

An asset's book value is an accounting value, representing the prevailing depreciation policy and accounting principles in certain legislation. Book values are generally determined independently from economic values. They are based on historic acquisition costs. Known as the Modified Accelerated Cost Recovery System (MACRS), the US depreciation policy assigns different recovery periods to certain classes of assets instead of using each asset's individual economic life in order to calculate depreciation allowances. As a result of the MACRS system, introduced after the 1986 tax reform, the depreciable life of assets has been shortened, so that businesses can increase their cash flows due to larger tax deductions. Thus the book value does not represent an asset's complete future earning potential since the depreciable life can be significantly shorter than the economic life span. The usefulness of book values in financial analysis is therefore limited.

Summary:

Discussing asset values requires careful definition of terminology used. The main concepts of asset values referred to in the following analysis will be economic value (base value) and market value (current and future). The economic value represents the NPV of future cash flows in an equilibrium market. The market value represents estimated or actual transaction prices of assets with regard to the prevailing conditions of supply, demand and the overall economic situation.

1.4 Basis for Discussion

The objective of this study is to show that aircraft value forecasts based on the capitalization methods are very sensitive to key variables. If changes in some variables such as load-factors or the cost of capital result in significant variations in an aircraft's value, can the NPV methods yield accurate results? The calculations of net cash flows for the NPV analysis, require the forecast of revenues and costs for up to 30 years. Looking backwards only 10 years, the volatility of the airline business is easily recognized. The accuracy of 30 year forecast is therefore very doubtful. The industry does not have a united opinion about its short-term profitability perspectives. While analyst predict an over capacity and yields are already diminishing in 1999, the airlines continue to add seats to the system.

The second objective is to evaluate the NPV methodology in the light of historic and current forecast results. The analysis aims also to explain the importance of cyclical swings in the airline industry resulting from supply and demand imbalances. It is examined if the cyclicality is incorporated by the appraising industry in their forecasted aircraft values.

1.5 Methodology

Due to the fact that forecasting aircraft values is a very complex issue, a significant part of this paper is dealing with explanations regarding the topic. From the question who needs aircraft values over factors affecting aircraft values to the techniques used in the aircraft appraising industry the author provides an extensive overview of the topic. Three research areas will be examined in the chapters following the coverage of the literature and the fundamentals of appraising theory.

I. Survey about aircraft value expectations of industry's leading appraisers

II. Forecast accuracy analysis and comparison for three forecasting models

III. Application of a NPV technique and Sensitivity Analysis

I. While the appraisers use different CMVs and also individual forecasting models, it would be interesting to see how much variance their projections bear in comparison to each other. Due to the lack of experience combined with an incomplete understanding of the aircraft finance market, most lenders depend on the appraisal industry. Banks are mainly interested in short-term gain. To realize the gains investors need accurate information about the asset current and future values. In order to find out if there is agreement in the industry regarding future aircraft values this survey was conducted. It was essential to define exactly what data was needed. In the survey the aircraft engine combination and the year of manufacture were specified. Furthermore, the appraisers were asked to provide the most likely trading values for aircraft in half-life condition. June 30th 1998 was asked as the reference date.

Different inflation rates could result in wrong interpretation of the compared data. In order to find the constant dollars values, the current dollar figures will be discounted at the inflation rates, assumed by the appraisers. The constant dollar values will represent the expected values depending on the revenue generating capacity and the market regardless of the applied inflation rates. The base values are supposed to reflect equilibrium markets, which in reality occur very seldom.

The following list includes the year of manufacture, the type, and the engines of the analyzed aircraft (Table 1). There are two reasons why new aircraft are not included in this survey. New aircraft have a very specific depreciation pattern during the first years and they not traded frequently.

Table 1

Survey Aircraft Types

YoB	Aircraft type	Engine type
1989	B-737-300	CFM56-3 B2
1986	MD-83	JT8D-217/219
1978	DC-10-30	CF6-50 C2
1990	B-757-200	RB211-535E4
1980	B-747-200B	JT9D-7
1982	A300B4-200	CF6-50C2
1991	A320-200	CFM-56-5A

The forecasted aircraft values will be sorted by aircraft type and then plotted along a time axis. The variance can then be determined by the calculation of the mean and the standard deviation for each aircraft type. This information is also useful for the analysis by aircraft size. By dividing the aircraft into two groups, wide-bodies and narrow-bodies, it will be possible to see if the variance in the appraiser's forecasts depends on the aircraft size.

II. Measuring forecast accuracy is not an easy task. Obviously one can only evaluate historical forecasts because the outcome of today's prognostication will not be available before the actual point in time.

In order to measure the accuracy of a forecast made in the past, one needs to compare each actual aircraft CMVs with the forecasted values. As will be explained in a following chapter, it is hard to find one current market value for a specific aircraft type delivered in a certain year. Appraiser's CMV estimates can vary significantly. Actual transaction data for an aircraft type of the same age, if available, can only be found as a range of values, because of different technical conditions and specifications. Real transaction prices reflect aircraft's different technical conditions and configurations but depend also on the negotiation skills and bargaining power of the parties involved. It is important to understand that it is impossible to compare someone's forecasted value with one single actual value, because such a single value does not exists. The CMVs available from different sources show a high degree of variation.

One possibility to calculate the forecast accuracy is to assume that one appraiser's historical CMVs are correct. Then, it is possible to compare the forecast of this appraiser with its CMVs and calculate the deviation. Another approach would be to take a pool of appraisers and calculate the average of historical market values. The later approach is not practical because data availability is limited.

There are several methods to determine forecast accuracy. Possible accuracy analysis could be conducted by year of forecast, by forecast horizon, by aircraft type, by aircraft groups or by a combination of these criteria.

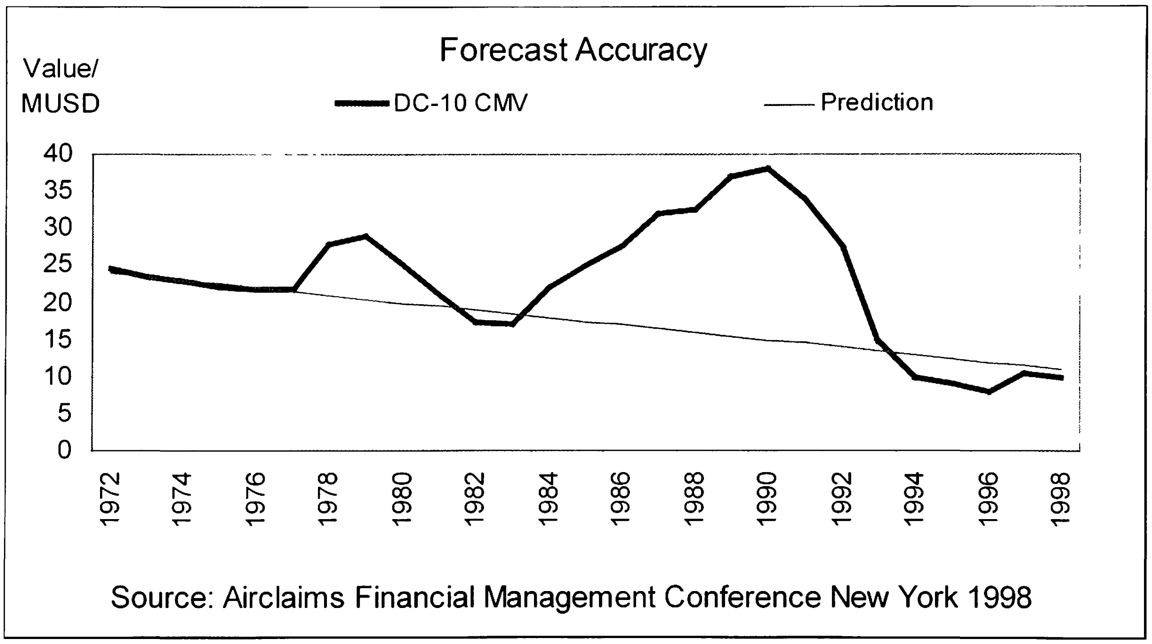


Figure 3. DC-10 Current Market Values and Forecasted Values.

Since the aircraft values are correlated to the airline industry cycles it is critical to evaluate a forecast on a long-term basis. As can be seen in Figure 3, a forecast can be very accurate for a short period but inaccurate in the long run. The Graph shows a fictive straight line value forecast from 1972 and the actual market values for a DC 10. A shortage on the supply side resulted in increasing values during the late 1970's and late

1980's. Due to the fact that the boom periods of the airline industry were not incorporated in the straight line appraisal, the forecast accuracy during theses periods was very low. Analyzing this fictive forecast, it can be found that most of the actual values vary considerably from the forecasted values. The mean of the error in that example is approximately 31%. However, for the first 5 years the average error is only 0.5%. For one forecast, the accuracy results can be very different if the criteria are changed.

In order to find comparable results, the author choose to use the forecast horizon and individual aircraft types as criteria in the forecast accuracy analysis. Thereby it is possible to find how large the error is in relation to the forecast horizon. For one specific aircraft type, build in year X a row of consecutive forecast is examined. All forecasts with a one year horizon are then compared with the actual values. The average of these forecast errors is calculated and specifies the accuracy of the appraisal for a one year forecast horizon. The same procedure is applied to two-year, three-year, etc. forecast horizons. In addition to the mean, the standard deviation for each forecasting horizon is calculated, too. Finally, the mean and ± 1 standard deviation are plotted with the forecast horizon on the X-axis and the percentage on the Y-axis. Figure 4 shows an example of such a graph. Knowing the specific error and also the standard deviation for a certain period enables an investor to evaluate the risk of a deal. After determining the forecasting accuracy for each of the 7 aircraft types specified earlier for the survey, the accuracy can also be used to evaluate both narrow-bodies and wide-bodies. The only problem occurs if recent forecasts are analyzed. For example, values projected in 1995 can only be compared with the 1996, 1997, and 1998 data. Consequently, only three forecasts would determine the average forecast accuracy for 1995. The problem of loosing statistically significance when using only a few data points can be avoided by neglecting the most recent forecasts. Therefore, only the first half of each forecast period is used to determine the accuracy of the model. For a better understanding of the technique used an example will now be discussed in detail.

In the first row of Table 2 it is specified in which half of the year each forecast started. The second row represents the CMVs at the time of the forecast. These are the actual data, which will be compared with the forecasted data listed in each column. The first column contains the forecast horizon in years. For 1993, the forecast horizon is 5.5 years and decreases to 0 for 1998. Thus, the further back the forecast was made, the more data is available to be compared with actual historic market values. Each forecasted value has a corresponding actual CMV listed in the first row. In 93/1 the predicted value for 93/2 was $26.07 million. With the corresponding actual value in 93/2 being $27.50 million, the error was $-1.43 million or -5.5% (Gray fields in Table 2). This forecast error in percent is listed in the 3rd row/4th column in Table 3. The result of each comparison is listed in the calculation sheet (Table 3) where the mean of the error and the standard deviation for each forecasting horizon is calculated. Mean and Standard deviation can be used to determine the confidence level for each forecast horizon. Due to an insufficient number of values, forecast horizons resulting in less than 4 comparisons (gray cells) are excluded from the analysis. A simple transition of these tables into graphs is helpful in determining the forecast accuracy. Figure 4 visualizes the variation of forecasted and actual values.

Table 2

Example of Input Sheet for Historical Forecasts of Aircraft Values

Horizon years	Forecasts from 1993 (first half) to 1998 (second half) / (million $US)												
	93/1	93/2	94/1	94/2	95/1	95/2	96/1	96/2	97/1	97/2	98/1	98/2	
0.0	27.50	27.50	27.40	27.40	27.20	27.20	22.27	20.74	22.14	21.50	22.00	21.50	CMVs
0.5	26.07	25.90	25.39	23.72	23.52	22.39	22.15	20.98	22.71	22.20	22.74		
1.0	24.63	24.50	24.12	22.78	22.94	22.24	22.31	21.36	23.30	22.81			F
1.5	23.35	23.38	23.24	22.25	22.76	22.34	22.60	21.76	23.82				O
2.0	22.33	22.58	22.73	22.06	22.80	22.53	22.90	22.09					R
2.5	21.60	22.10	22.51	22.06	22.93	22.74	23.14						E
3.0	21.15	21.88	22.47	22.13	23.08	22.89							C
3.5	20.93	21.81	22.49	22.21	23.17								A
4.0	20.84	21.78	22.52	22.24									S
4.5	20.80	21.76	22.50										T
5.0	20.76	21.71											
5.5	20.69												

Source: Data created for Example

Table 3

Example of Mean and Standard Deviation Calculation Sheet

Horizon years	MEAN	STDEV	Mean Error Calculation Sheet for Table 2 Data											
			93/1	93/2	94/1	94/2	95/1	95/2	96/1	96/2	97/1	97/2	98/1	98/2
0.0	0.00%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.5	-3.31%	7.72%	-5.5%	-5.8%	-7.9%	-14.7%	-15.6%	0.5%	6.4%	-5.5%	5.3%	0.9%	5.5%	
1.0	-3.42%	9.48%	-11.2%	-11.8%	-12.8%	-19.4%	2.9%	6.7%	0.8%	-0.7%	5.6%	5.7%		
1.5	-3.06%	11.03%	-17.3%	-16.3%	-17.0%	-0.1%	8.9%	0.9%	4.9%	-1.1%	9.7%			
2.0	-2.52%	11.56%	-21.8%	-20.5%	2.0%	6.0%	2.9%	4.6%	3.9%	2.7%				
2.5	-0.37%	11.79%	-25.9%	-0.8%	7.9%	-0.4%	6.2%	3.3%	7.1%					
3.0	2.50%	4.17%	-5.3%	5.2%	1.5%	2.8%	4.7%	6.1%						
3.5	2.39%	3.42%	0.9%	-1.5%	4.4%	0.9%	7.2%							
4.0	0.17%	4.35%	-6.2%	1.3%	2.3%	3.3%								
4.5	-0.01%	4.02%	-3.4%	-1.1%	4.4%									
5.0	-2.50%	4.91%	-6.0%	1.0%										
5.5	-3.91%		-3.9%											

negative data represent underestimated forecasts / positive data represent overestimated forecasts

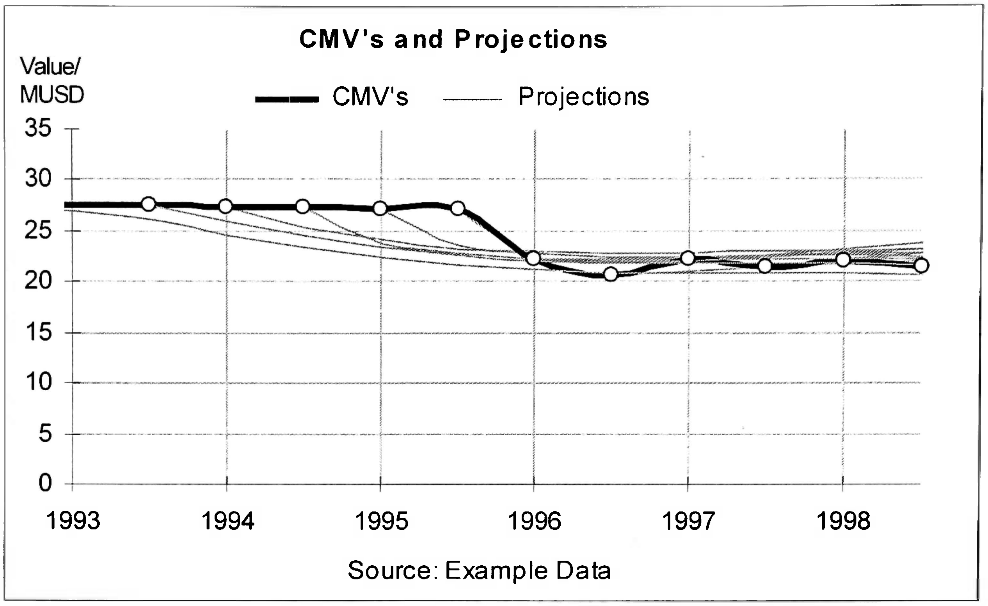


Figure 4. Historic Market Values and Biannual Forecasts.

In this example the forecasted values were to low before 1996. After that year the gray lines are very close to the black line which is a sign for very high forecasting accuracy. The mean of the error and the standard deviation for each forecast horizon, as calculated in Table 3, is easier to evaluate when plotted in a graph. From Figure 5, it can be recognized that for a forecast horizon of up to 3 years the mean of the error is relatively consistent by about negative 3%. A standard deviation as low as 10% is also an indicator for good accuracy. The upper and lower gray lines represent ±1 standard deviation while the bold black line represents the systematic error. Assuming a normal distribution of the error, it can be concluded that in 68% the forecast was within ±1 standard deviation. For example for values projected 2 years ahead, only 32% of the

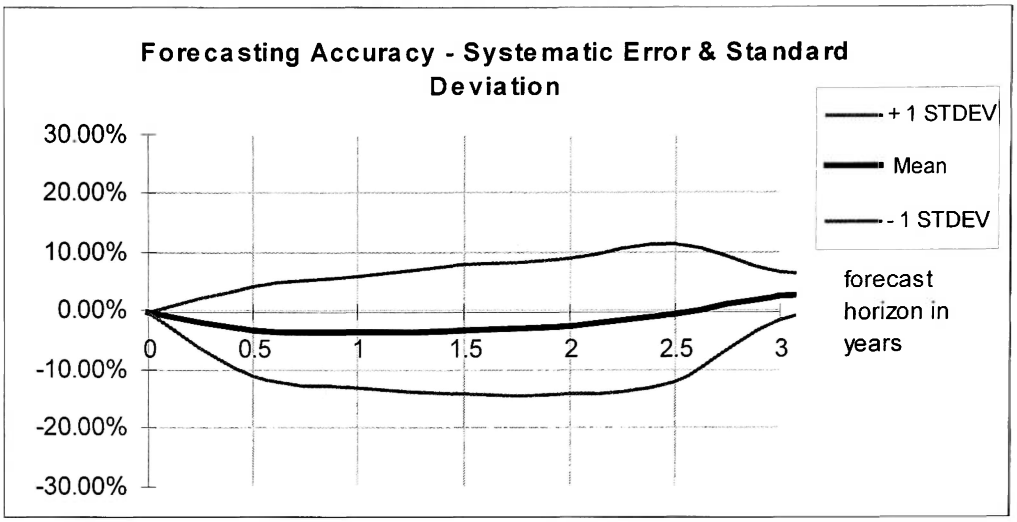


Figure 5. Mean and +/- One Standard Deviation of an Example Forecast.

predictions were more than 11.6 % off the actual values. This analysis will be conducted for each of the 7 aircraft types examined in this paper.

III. The third part of the analysis is a practical application of the NPV technique. The essential inputs to a NPV analysis are future cash flows. In the analysis revenues and expenses from 1985 to 1998 build the foundation for the cash flow determination. By adding a trend-line, the expenses and revenues per available seat mile (ASM) can be extrapolated, so that 30-year operating time frame can be simulated. Using B737 operational data and historic utilization data of this equipment, the ASM can be determined. By multiplying 365 days with average industry data of daily hours of utilization, seating capacity and block-speed ("average speed in statute miles per hour of an aircraft, between the time the aircraft first moves under its own power for purposes of flight until it comes to rest at the next point of landing", Wells, 1999), the historic average ASMs for the B737 used in the example, can be determined. By adding a trend-line to the result the future ASMs can be projected. From an analysis of the utilization of old equipment by major airlines, it was found that the utilization of old equipment has a decreasing tendency. This trend is incorporated in the prediction of the ASM. The multiplication of the ASMs with difference of revenue per ASM and the expenses per ASM leads to the net cash flows. Discounting and adding the expected cash flows to the date of the evaluation returns the value of the aircraft. Using this example as a base case, a sensitivity analysis can be conducted in order to show the influence of the discount rate. The data for these calculations are available from the Airline Monitor and the Air Transport Association of American (ATA).

In order to analyze the impact of the different cost and revenue components, such as fuel-cost, labor-cost or load factors, a scenario analysis is conducted. Using a NPV model designed and provided by Edmund Greenslet, the editor of the Airline Monitor, the impact of changes in input variables on aircraft values can be found. As Table 4 shows, cost and revenues in the model are broken down into their main composites. In the version of the model used, 1993 data are actual while the years before and after are decreased or increased by an escalation formula developed from historical data.

Table 4

Variables Examined in an NPV-Scenario Analysis

Revenue variables	Expense variables
Yield	Flying Labor / Block Hour
Utilization	Fuel per Gallon - ¢
Loadfactor	Fuel / Block Hour
	Maintenance / Block Hour
result in	
Passenger Revenue	Block Hour Cost
Cargo & Other Revenue	Marketing, General, Administration, etc.
	Ownership Cost
SUM = TOTAL REVENUE	SUM = TOTAL EXPENSES

2 Literature Review

This chapter gives an overview about general topics related to aircraft appraising and also about research literature related to the application of the NPV method to aircraft value modeling.

2.1 *History of value theory – Economical view*

Although slightly deviating from the main topic, asset valuation and valuation theory, the contribution of popular economists on value theory is helpful in understanding today's valuation methodologies. While valuation theorists concentrate on identifying the sources and basis of worth in an asset, valuation theory is the process of estimating the specific value of any asset. Value theory is considered the root of valuation theory.

Comparative methods or reproduction cost methods were the techniques frequently applied in the early stages of valuation. An expression used at this time was the *just price*. Just price was supposed to be equivalent to the cost of labor required to produce a specific good.

William Petty (1627 1687), a pre-classical scientist attempted to objectively explain laws of reality. Part of his studies included defining market value. Petty believed that dependent on factors of production, land and labor, the actual price of any asset was continuously fluctuating around the natural value. It was Richard Cantillon (1688 - 1734) who had a similar idea and developed the land theory. According to Cantillon, the intrinsic value of any good could be expressed in units of land. He used a model to transform the amount of labor into units of land. Nicholas Barbon (1640 -1698) was convinced that the value of a good was equal to the market price, which he thought to be determined by the supply of articles available (Fogarty, 1996). Barbon further stated that the value of all wares was determined by their use and that useless items had no value. Since he differentiated between two general wants desired by mankind, the wants of the body and the wants of the mind, he inferred that all things are useful and therefore have a value. He believed that the surplus of a ware resulted in low values and conversely, scarcity drove prices up (Barbon, 1690).

In contradiction to Petty and Cantillon, John Locke (1632-1704) found land to be valueless and labor to be the determinant of value. While also recognizing also the forces of supply and demand, Locke was convinced that labor was the equivalent of production cost and that labor was the only source of value. The most popular classical economists, such as Adam Smith (1723-1790), John Stuart Mill (1806 1873), David Ricardo (1772-1823) and Karl Marx (1818-1883), emphasized cost of production and sacrifices as main determinants in their value theories (Wendt, 1974). Applying the "water diamond paradox" used by John Law (1772 - 1823) in his explanations on demand and supply theory, Adam Smith found that "labor is the real price and money is the nominal price" (Meek, 1973). According to Marx the value of a commodity is determined by the amount of sacrifice and labor it contains (Ballard, 1995). Toward the end of the 19th century, the Neo-Classical era, it seemed that scientists finally found a method explaining value. William Jevons (1835 1882) and Carl Menger (1840 - 1921) in 1871 developed the marginal utility theory. Their main thesis was that "value depends entirely on utility"

(Fogarty 1996). Leon Walras (1834-1910) did not agree to this simple causal link between utility and value. His theoretical model of General Equilibrium was an integration of cost of production (supply) and utility (demand). Walras' model included more complex interrelations between different variables and the economic system. It was Alfred Marshall (1842-1924) who resolved the controversy about the search for a single determinant for value. Marshall recognized the interdependence of utility and cost of production, and he took into consideration another variable: time. Marshall was the first one to apply the time factor to plant size and thereby to supply. This made supply the main determinant for value in the long term. In the short term, Marshall found supply to be fixed and value to be solely determined by demand.

It can be concluded that the historic debate surrounding the determinants of value persisted for so long because economists tried always to find a one-dimensional (supply-oriented) explanation for their value theories. After recognizing that value is a function of both utility and cost of production, Marshall became the pioneer of today's three basic valuation methods: replacement cost, market comparison, and capitalization of income.

While Marshall considered the discounted value of future returns only as the value for old machines (assets), it was Irving Fisher who defined value as "simply the present worth of the future income from the specified income" (Fisher, 1906). In 1930 Gustav Cassel subscribed to Marshall's and Fisher's capitalization of income theory, but added his principle of cost. In Cassel's opinion the actual price oscillates around a "normal condition" (Wendt, 1974). R. Bye, an advocate of Cassel's ideas, differentiated between ideal market conditions and actual market conditions. The theoretical value is also called normal value, such as calculated in the capitalization of income method. Both represent the value of a good in an ideal market, where supply and demand are in equilibrium. The actual value or market value is higher or lower than normal value since in reality demand and supply are seldomly in equilibrium. During the 20^{th} century, economists examined the behavior of values and prices under various conditions. Finally, today's economists place emphasis mainly upon the determination of prices for new products (Wendt, 1974).

2.2 Asset Valuation – Financial concepts

For any business the motivation for an investment is to generate positive cash flows. The price or the value of an industrial good like an aircraft should therefore represent the income generating potential covering the cost incurred as well as the profit generating capacity. Due to the fact that capital investments have long-term characteristics, investment decisions need to take into account the time value of money. Also, the investment decision's compatibility with the company's strategic perspective and the economic impact on a firm's overall performance need to be taken into consideration. In contradiction to capital expenditures, which result in benefits for the following year only, the process of planning and managing a firm's acquisitions of assets creating returns in excess of one year is called capital budgeting (Ross, 1993).

Substantial in-depth analysis is required to make capital budgeting decisions, as theses decisions determine a firm's future direction. A wrong decision can have severe consequences and generally not reversible without incurring high costs or write-offs. An example is a small airline taking delivery of a new wide-body jet during a recession. Due to low load-factors, the aircraft would not generate the desired cash flows. If the airline decided to sell the aircraft in order to pay debt it might face a low resale value since demand for wide-body aircraft would be very low in times of diminishing load-factors. As a result, the airline would incur a high loss on behalf of the wrong investment decision.

The time value of money:

Cash flows can vary in magnitude as well as in timing. Thus, it is necessary to compare cash flows in different points of time. According to the equivalence concept, the value of a sum of money today is equal to a different sum of money in the past or in the future (Figure 6).

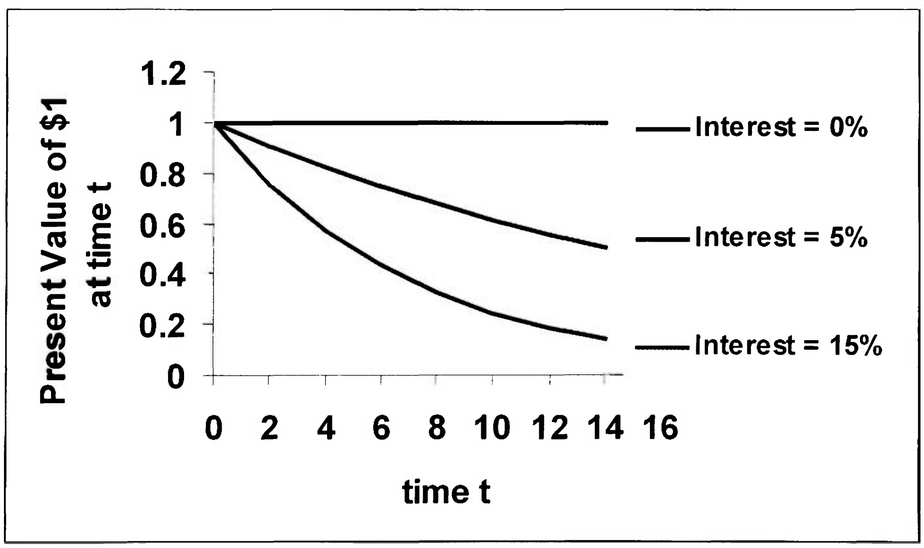


Figure 6. The Time Value of Money.

In other words, one unit of money possessed today is worth more than the same one unit in the future. The difference between the value of $1 today and $1 in the future is a function of time and cost of capital. The explanation for the time value of money concept is that a dollar invested in $t=t_0$ can be invested and generate at least the interest paid by a bank. For the case that the money is invested longer than one investment period ($P>P_1-P_0$), the interest earned in the first period can be added to the principal and generate additional interest in the second period. Earning interest on interest is called compounding process (Harvey, C. R. 1998). Compounding is used in the process of finding the present value (PV) of future cash flows (FV). The present value is a tool to compare cash flows independently from their timing (Moyer, 1990).

$$PV = \frac{FV}{(1+k)^t} \qquad (1)$$

k = discount rate / (interest)

t = number of time periods

In order to evaluate different investment options returning different cash flows at different points in time, the present value concept is an essential tool.

Net Present Value:

For real investment projects, including inconsistent series of cash inflows and outflows, a more sophisticated concept needs to be applied. Widely used for investment analysis, the NPV is used to find an investment's expected value in current dollars after deducting all arising costs (Moyer, 1990).

$$NPV = \sum_{t=0}^{n} \frac{NCF_t}{(1+k)^t} \qquad (2)$$

NPV = present value of the project

NCF = Net cash flow (Inflows - Outflows)

k = cost of capital (required rate of return / riskiness of the estimated cash flows)

t = year

n = expected project life

Costs such as interest are not included in the incremental cash flows. The discount rate reflects the cost of capital, which is the minimum required rate of return for a project in that risk category. In order to determine if the project is profitable, future cash flows are discounted at the required rate of return, which is equal to the cost of capital. The market-determined required rate of return depends on the market's perceived level of risk associated with the investment. The market valuation theory reflects the process of adding a risk premium, generally the market average, to the risk free rate. The discount rate derived from the CAPM reflects the return required by investors for a project's specific risk. Figure 7 displays the market valuation process.

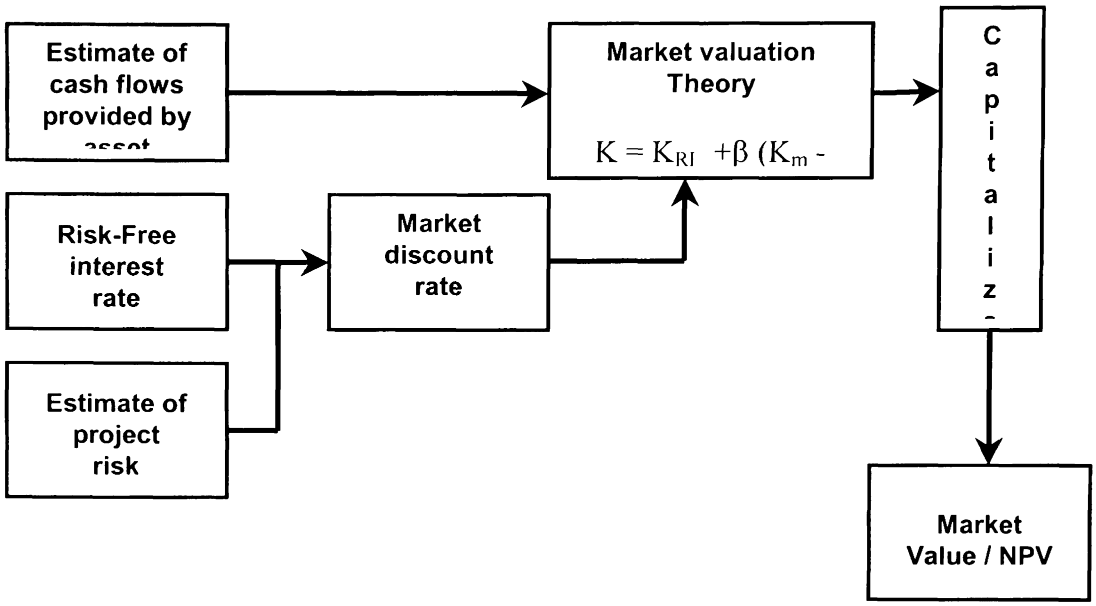


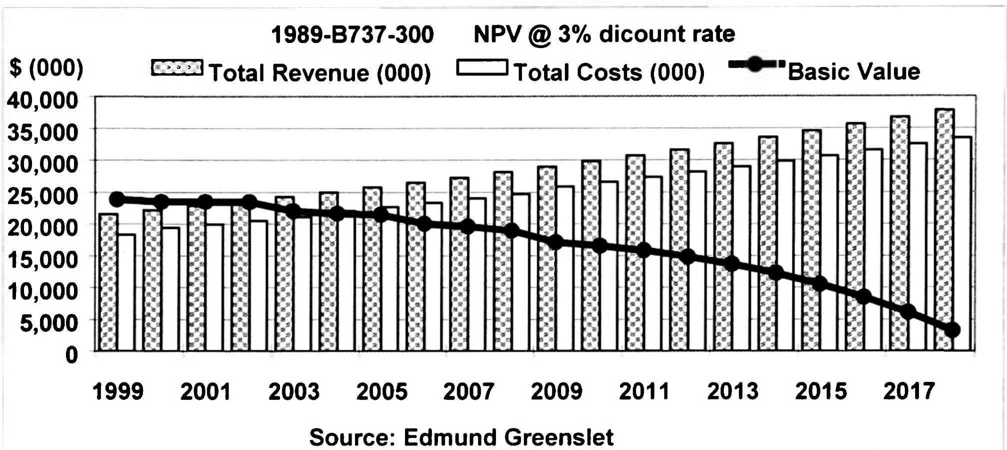
Figure 7. Market Valuation Theory.

$$K = K_{RF} + \beta\ (K_m - K_{RF}) \qquad (3)$$

The expected return of an individual security (K) is equal to the current risk-free rate (K_{RF}) plus the Beta of the security (β) multiplied with the historical market risk premium (K_m - K_{RF}) (Ross, 1993).

The estimated future cash flows of a project are discounted at the rate derived form the market valuation theory in order to find the NPV or market value. A positive NPV represents additional wealth created by the project.

In Figure 8 the NPV or the black line represents the value of an aircraft. By discounting the future net cash flows (total annually revenue - total annually cost = net cash flow) for each year, the NPV's or aircraft values for each year in the future can be derived.



Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Revenue (000)	21,540	22,186	22,852	23,537	24,243	24,971	25,720	26,491	27,286	28,105
Costs (000)	18,276	19,410	19,941	20,489	21,055	22,059	22,677	23,314	23,972	24,652
Profit (000)	3,264	2,776	2,911	3,048	3,188	2,911	3,043	3,177	3,313	3,453
Basic Value	**23,877**	**23,479**	**23,520**	**23,431**	**22,035**	**21,651**	**21,483**	**20,056**	**19,604**	**18,974**
Year:	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Revenue (000)	28,948	29,816	30,711	31,632	32,581	33,558	34,565	35,602	36,670	37,770
Total Costs (000)	25,852	26,594	27,359	28,149	28,965	29,807	30,677	31,575	32,501	33,458
Pretax Profit (000	3,095	3,222	3,351	3,482	3,616	3,751	3,888	4,027	4,169	4,312
Basic Value	**17,136**	**16,561**	**15,810**	**14,858**	**13,681**	**12,249**	**10,531**	**8,490**	**6,086**	**3,273**

Figure 8. Aircraft Values for a 1989 B737-300 as a Result Net Cash Flows.

Internal Rate of Return (IRR):

The IRR represents the discount rate, which leads to a break even of future cash flows with the initial investment. The IRR is the discount rate at which a project's NPV is equal to zero. Therefore the IRR specifies the minimum required rate of retro for an investment.

$$NPV = \sum_{t=0}^{n} \frac{NCF}{(1+IRR)^{t}} = 0 \qquad (4)$$

2.3 Related research literature

Leading Indicators for Aircraft Valuation (van Donselaar, 1998):

M. van Donselaar examines factors affecting aircraft values. He distinguishes between three categories: macro-economic, meso-economic and micro-economic factors. In the category of Macro-economic indicators, world gross domestic product (GDP) is defined as the most important leading indicator for used commercial aircraft. The International Monetary Fond predicted a 3.7% GDP growth rate for 1999 and an average of 4.5% for the year 2000 to 2003 (van Donselaar, 1998). During the three major recessions since 1970, the GDP growth level was lower than 2%. The GDP affects the four remaining leading macro economic indicators which are: world traffic growth, load factors, world fleet size (orders, deliveries and retirements) and interest/inflation rates. In addition to these five main macro indicators, van Donselaar defines incidental factors as the leading indicator for used aircraft values. The Asian economic crisis had such an incident that the over capacity in the region resulted in airlines to dispose surplus capacity. An increased supply of wide-body aircraft was expected to result in prices to drop. Interest/inflation rates were not found to be leading indicators because no significant correlation to aircraft values was found (van Donselaar, 1998). As meso-economic indicators van Donselaar lists old and new technology, oil price, narrow and wide-body aircraft, regulation and deregulation and noise legislation. According to his analysis, oil price has a 20 to 40% share of operating cost, which makes it the leading meso-economic indicator. Noise legislation ranks second and regulations rank third in degree of importance. Aircraft size and age of technology are not found to be meso-economic indicators for aircraft values.

For the third category, micro economic indicators for aircraft values, van Donselaar found four factors. While the meso-indicators were related to the aircraft model, three micro indicators determine the value of one specific aircraft. The aircraft's age and newness is defined as the first leading indicator. The second group of micro-indicators include the aircraft's physical condition, its maintenance status and maintenance documentation. Of these factors, only documentation has leading character. Operational flexibility and modification ability form the third group of factors which are ranked as the leading indicators. Aircraft acceptance is micro-indicator number four, but it refers to a specific aircraft as well as the aircraft type. Acceptance of an aircraft type depends on its stigma, and hard- and soft factors. The hard factors are the operator base and the total number of aircrafts built and in service. Soft factors are early availability, family concept and image of other customers. An aircraft's stigma depends on special situations such as operating conditions, repairs or an aircraft type's reputation in regard to safety. All four micro-indicator groups are considered important.

The macro-economic indicators are extremely important because they are indicators of the aviation industries cycles, which have the most impact on aircraft values. The micro-indicators "only" determine the exact value of a specific aircraft in regard to the timing of the industry cycle.

Empirical Valuation Models: How Useful Have They Been? (Karathanassis, 1983):

Research conducted about aircraft valuation is very limited. Therefore, literature regarding asset valuation theory is examined in this chapter. One of the most common forms of valuation is share valuation. The concept of investing in any asset is the same since the investors expect a return on their investment. Karathanassis believes that share valuation models are not properly specified by researchers. The share value in statistical models is generally based on a combination of the following factors: dividends, retained earnings, growth, risk gearing and size. Karathanassis is concerned about the practical applicability of the valuation theory since theorists make a lot of fundamental assumptions. Share values are defined as a function of expected perpetual benefits. Algebraically, the market price can be expressed as:

$$p = \frac{e}{\mathrm{k}} = \frac{e}{(1+\mathrm{k})^1} + \frac{e}{(1+\mathrm{k})^2} + \ldots + \frac{e}{(1+\mathrm{k})^n} \qquad (5)$$

where p is the unobserved expected value of earnings per share and k is the marginal discount rate. The price of a growth share is expressed as:

$$p = \frac{e}{\mathrm{k}} + \frac{be}{k}\left[\frac{r-k}{k}\right] \qquad (6)$$

where b is a constant retention ratio and r is the rate of return on new assets. The predominant opinion among financial experts is that the share price is determined by dividends and not by earnings. The formula for the share price using dividends is:

$$p = \frac{e\left(1-\text{b}\right)}{\text{k}} + \frac{be}{k}\left[\frac{r}{k}\right] \qquad (7)$$

Karathanassis claims that Equation 6 and 7 have never been tested by researchers and that it is not proven whether the dividends hypothesis or earnings hypothesis is more valid. He concludes that economic and statistical models were badly specified and thus these empirical models are not very valuable.

<u>The Relationship between Investment and Asset life (Prezas, 1994):</u>

Prezas describes a model, which shows that optimal investment and optimal asset life are interdependent through operating cash flows and depreciation allowance, as well as book and salvage values up to termination. In contradiction to existing literature, Prezas shows that optimal investment and asset life are determined simultaneously. Other models use a predetermined investment in order to find the optimal asset life or a predetermined asset life in order to optimize the investment. In both variations Prezas claims that exogenously fixed factors result in NPV's to be not maximized. Only the simultaneous consideration of investment and asset life leads to a project's maximum NPV and asset value. If an extension of the holding period increases the benefits of marginal investment, asset life and investment are positively related. According to Myers and Majd, a firm has the option to change the duration of asset life in the event of future cash flows and salvage values deviating from previous expectations. If the over capacity of the early nineties could have been foreseen, project termination could have resulted in higher returns than continuation at low operating cash flows during the recession. Optimal investment and asset life increases with the use of riskless debt because benefits of marginal investment increase and cash flows generated by asset termination become reduced.

Prezas' model is based on the equation 8 where V reflects "the asset's NPV of unleveraged after-tax future cash flows (including depreciation tax shields), plus the present value of the after-tax salvage value (including book value tax shields), less the assets initial cost.

$$V(I,T;L,\alpha,\tau) = \int_0^T [(1-\tau)X(I,t) + \tau D(\alpha,I,T)]e^{-kt}\,dt$$
$$+\{S(I,T) - \tau[(S(I,T) - B(\alpha,I,T)]\}e^{-kt} - I \qquad (8)$$

I = Investment

L = market value leverage ratio

t = time of asset's life

τ = corporate tax rate

r = unlevered cash flow

D = cost of debt

k = required rate of return = k = r-τrDL

cost of per unit of investment = 1

X(I,t) = unleveraged operating cash flow

T = abandonment time

D(α,I,t) = depreciation allowance at time t

B(α,I,t) = asset's book value

S(I,T) = salvage value

α= holding time

From the first order conditions of this function Prezas finds the optimal values for investment (I) and abandonment time (T), maximizing the assets value.

"Free Cash Flow" Appraisal . . A better way? (Brown, 1996):

There has been more research conducted about real estate appraisal than about aircraft appraisal. For that reason, Gordon T. Brown's paper concerned with cash flow analysis in real estate appraisals, is included in the literature review. Brown criticizes the traditional way of net operating income capitalization for a given property in order to find the market value. He recommends an increased application of the traditional income approach. Free cash flows should be defined and thoroughly examined in order to produce quality income property appraisals. Insufficient attention has been paid to the cash flow itself. Often the final earnings are measured instead of defining the direction and amount of cash funds. Cash flow statements reveal the exact operating, investing and financing activities related to a real estate enterprise. "Free cash flows are cash flows generated by the current operation of a business or real estate venture and are available to be distributed back to the owners/shareholders without affecting current levels of growth. The purpose of free cash flow analysis is to determine the condition of the enterprise, after extraneous items, non-repetitive items, and accounting variations are removed. By applying the free cash flow analysis discretionary and non-discretionary activities and expenditures for each of the operating, investing and financing categories, can be identified. By quantifying the cash impact the underlying earning power of a single real estate asset can be determined. The net operating income can be misleading as revenues, expenditures, assets or liabilities might not be fully included, or have only little relationship to the enterprise. A further objective of free cash flow analysis is to find the optimal balance debt and equity financing for the real estate venture. The volatility of historical free cash flows should be measured in order to predict if free cash might be needed to cover operating or investing activities. While the free cash flow method is only a theory, the accuracy is expected to be much higher than those of traditional cash flow appraisals. "Free cash flow analysis allows the examiner to take a critical look at the current level and at the future direction of those cash flows both in terms of quantity and quality" (Brown, 1996).

Capital Asset Valuation for Stochastically Deteriorating Equipment (Jones, 1992):

Jones, P., Hopp and W., Zydiak, J (JHZ) have developed a capital asset valuation theory for stochastically deteriorating equipment that provides the asset's economic value. Traditionally, capital asset valuation theory is based on two assumptions: Equipment deteriorates deterministically and there is an active secondary market (resale) for the equipment. JHZ's model is developed for stochastically deteriorating equipment for which there is no active secondary market. The model seems interesting for the discussion of aircraft values, since the secondary market for aircrafts are not transparent and depreciation patterns are not exactly known either. According to the user-cost theory, value of durables is derived from the services they provide, not from the durables themselves. Jorgenson and Johnson found that user-cost theory provides an explanation for empirically observed demand for durables and that it can be applied to define economic depreciation. Stochastic deterioration has the advantage that it accurately models real systems. Brealey and Myers observed that the market for many corporate assets are too thin to derive economic value from the market prices. The same is true for aircraft values where there is not sufficient information about resale prices available.

The model is based on the following equations:

$$EPC_i(\sigma_\tau) = \frac{\sigma_\tau(i)[m_i + \delta \sum_{j=i+1}^{n} \pi(i,j) EPC_j(\sigma_\tau)] + (1-\sigma_\tau(1))(-{}_i s_i)}{1 - \delta\sigma_\tau(i)\pi(i,i)} \quad (9)$$

EPC = expected present cost of operating a machine in state i and operating it until it is replaced according to replacement policy σ_τ;

$\pi(i,j)$ = probability that a machine is in state i that is kept in any year will be in state j in the following year;

σ_τ = replacement policy;

${}_i s_i$ = salvage value of a machine in state i;

m_i = opportunity cost (including maintenance, operating and obsolesce) of keeping a machine in state i;

$\delta = 1/(1+r)$, where r is the effective annual interest rate (δ is called the discount factor)

τ = state of the machine;

$$\alpha_i(\sigma_\tau) = \frac{\sigma_\tau(i)[1 + \delta \sum_{j=i+1}^{n} \pi(i,j)\alpha_j(\sigma_\tau)]}{1 - \delta\sigma_\tau(i)\pi(i,i)} \quad (10)$$

$\alpha i(\sigma\tau)$= expected present cost of cash flow stream;

$$y^*_\tau(\sigma_\tau) = \frac{p_\tau + EPC_\tau(\sigma_\tau)}{\alpha_\tau(\sigma_\tau)} \quad (11)$$

$y^*\tau(\sigma\tau)$ = amortized annual cost of the machine over the expected replacement cycle;

$$y^{**}(i) = \frac{y^{*} - m_i + \delta \sum_{j=i+1}^{n} \pi(i,j)\, y^{**}(j)}{1 - \delta\pi(i,i)} \qquad (12)$$

y** = economic value of capital asset subject to stochastic deterioration;

"Since y* is the expected annual equivalent cost of operating a machine over its expected replacement cycle, y* is the expected marginal cost of owning a machine in an arbitrary state i. For a firm that maximizes expected profits, expected marginal revenue is equal to marginal cost. Therefore, y* is the expected value of services provided by a machine in state i"

<u>Do Asset Fire Sales Exist? (Pulvino, 1998):</u>

Pulvino examines the impact of capital constraints on aircraft liquidation prices. Using Avmark's 1978 to 1991 transaction data for narrow-body jet aircraft, he determines the magnitude of discounts at which distressed airlines liquidate assets. After 1991, the Department of Transportation (DOT) did not require airlines to report transaction prices anymore. Subsequently to 1991, only voluntary disclosed information is available, transactions after 1991 were excluded from the analysis. Data on U.S. airlines were obtained from Compustat, company 10Ks and 10Qs, Moody's Transportation Manual, Air Carrier Statistics and the Capital Changes reporter. Hedonic regression was employed in order to analyze the data. Pulvino had problems finding the present net value of cash flows generated by the asset, which he called the fundamental value. "Empirical efforts to measure discounts at which assets are liquidated are complicated by the inability to measure fundamental values." The Schleifer and Vishny industry-equilibrium model of asset liquidation was also applied to the analysis. The model shows that discounts are high in depressed industries where the asset is very industry specific. During an industry wide recession, the market for industry specific assets is not liquid. In the airline industry the consequence would be that the demand for an aircraft with discounts so low, non-industry financiers become interested in the assets. Outsiders are not highest-value users, such as operators, and therefore they require higher discounts in order to compensate for the risk associated with finding a lessee. Pulvino found that during recessions, financial institutions are able to negotiate discounts of 30% compared to the average market price. Financially distressed airlines or airlines with low spare debt capacities need to offer a 14% discount to the average market price in order to stimulate demand. Findings of Pulvino also have implications for firms' capital structure decisions. Maintaining spare debt capacity for recessions may result in opportunities to acquire additional capacity at bargaining prices from industry fire sales.

2.4 Supply and demand of aircraft

Introduction

The price for any good in a free market is generally determined as a function of supply and demand, thus both factors will be discussed for the civilian aircraft market. While aircraft manufacturers comprise the supply side of the equation, airlines and leasing companies comprise the demand side. There exist many buyers in the market for large commercial aircraft, aircraft greater than 100 seats, but only two suppliers. As a result of consolidation and companies leaving the market, today there is only the European Airbus consortium competing head on with the Seattle based Boeing Company. Thus the supply side of new aircraft is characterized as a duopoly. After an explanation of the aircraft manufacturing industry's characteristic, an overview of the consolidation process and the history of the different international manufacturers in the industry will be given.

One important aspect in the Aerospace Industry is the total number of units one can produce annually. These annual unit volume shipments are relatively low compared to most manufacturing industries. As can be seen from Figure 9, the number of aircraft delivered worldwide peaked in 1991 and 1998 and did not surpass the 800 units ceiling. This low volume of production makes the automation of many manufacturing processes prohibitively expensive.

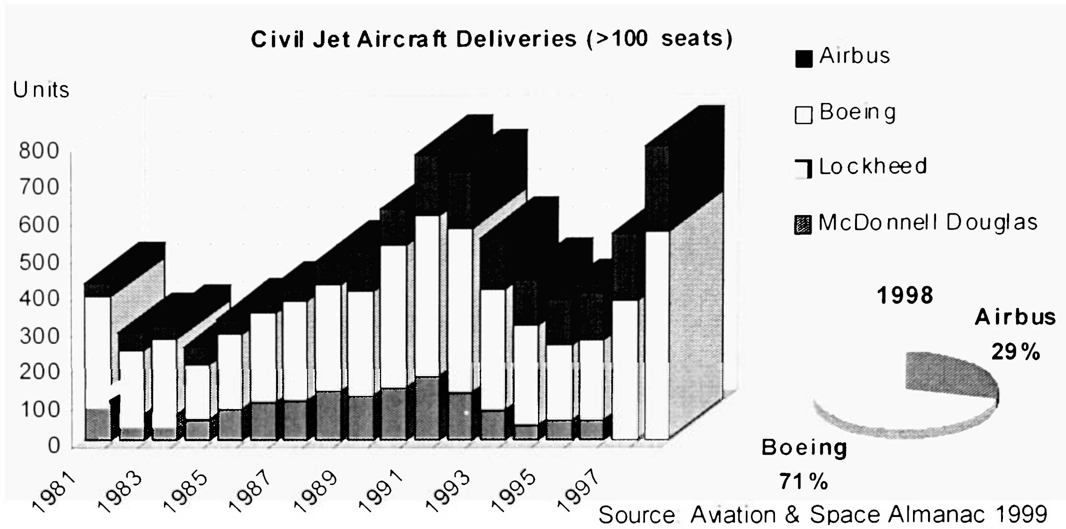


Figure 9. Commercial Jet Aircraft Deliveries.

The dominant producer of commercial jet aircraft is Boeing, who delivered an all time high of 563 aircraft in 1998. Still, economies of scale and automation options are very limited as each customer is ordering a highly customized product. The Industry assembles high-tech products but its assembly processes are fairly labor intensive, with relatively little reliance on high-tech production techniques. Assembling a highly customized product requires a massive labor force for production. The percentage of the Industry's workforce involved in craft and technical occupations is significantly higher than for manufacturing in general. Maintaining enough qualified employees in these positions is one of the Industry's chief challenges. Cyclical swings in airline demand dictate that the manufacturer's workforce needs to be periodically adjusted.

The cost of launching an all-new aircraft program today is higher than $5 billion. Generally, the break even point lies between 400 and 600 units which results in negative cash flows of each program for about 7 to 10 years (McGuire, 1997). The development costs for Airbus' A3XX are expected to accumulate up to $10 billion.

The aerospace industry can have a positive impact on a nation's economy. This can be illustrated by examining the industry's impact to the United State's economy. Aerospace exports worth $19.7 billion in 1986 represented 9.6% of total US exports. While in 1990, the industry contributed about $27 billion to the US trade balance, in 1996 exports of aerospace vehicles and equipment topped $37.4 billion with a positive trend. Thus, aerospace sales represented 16.7% of the total 1996-export value of $625.1 billion (Central Intelligence Agency, 1998).

The aerospace industry structure can be summarized by the following four industry characteristics: huge capital requirements, high technology know-how requirements, high labor intensity and cyclical demand. Overall there exists high barriers to enter the commercial aircraft manufacturing market.

2.4.1 Supply

The World wide structure of the commercial aircraft manufacturing Industry:

Asia:

Asian and Pacific Rim nations account for 20% of the world market for commercial aircraft. Despite the recent Asian economic crises, this market is expected to have the highest growth rates in the future while North America and European markets approach maturity levels. Due to the Asian economic crisis, defense and civilian aerospace budgets have become slashed, and a thinning out of the industry has become apparent (Handley, 1998). In South Korea the Government ordered the merger of the four aerospace companies: Samsung Aerospace Industries, Korean Air, Daewoo Heavy Industries and Hyundai Space and Aircraft Co. Most programs, such as the F-16 program depend heavily on government support (Handley, 1998). Plans for a civilian 100 seater are also canceled.

In Indonesia, Industri Pesawat Terbang Nusantara (IPTN) is suffering from less government support, too. There is some interest in the 60 to 80 seat N-250's but IPTN is in severe financial trouble (Handley, 1998). The capital required for the development of the 80 to 130 seat jet, the N-2130, is expected to fail due to financing problems (Handley, 1998).

Because of the Japanese defense budget reduction, 9% in 1998, the aerospace industry is focusing more on civilian products, which reached 45% of revenues. While the Japanese produce the F-2 jet fighter, they do not currently plan to build commercial jet aircraft by themselves (Handley, 1998). The Society of Japanese Aerospace Companies (SJAC) announced $8.3 billion revenues for 1998. Japanese aerospace suppliers provide 20% of parts and components for Boeing's B777 program. They are also suppliers for the B767 and the International Aero Engines V2500 programs (Handley, 1998).

Chinese Aerospace companies have been assembling trunkliners under license from McDonnell Douglas, but currently, they are mainly working as suppliers for Boeing or Airbus. In Shanghai, the Chinese assembled 28 MD-80 aircraft under license of McDonnell Douglas (Wells, 1999). The 100 seater A31X that was supposed to be manufactured in a joint venture of Airbus and Aviation industries of China (AVIC) failed because of discords regarding the know-how transfer and the work distribution of the project. Officially there does not exist enough demand in the 100 seater market. Singapore Technologies Aerospace also had ambitions to develop a mid-sized passenger jet in a joint venture with China, but the plan so far remains a "paper concept" (Handley, 1998).

Taiwan's main aerospace manufacturer, Aerospace Industrial Development Corporation (AIDC) is one of the few aerospace companies being privatized. AIDC is supposed to keep its role as a supplier and provider of aircraft services.

Russia/CIS:

In Russia there exist about 335 enterprises and organizations which represent about 80% of the former Soviet Union 's aircraft industry. The 19 large production plants and design bureaus have a capacity of manufacturing about 350 fixed wig aircraft and 300 helicopters per year (Butowski, 1998). In 1998 a total of only 45 aircraft has been assembled (Butowski 1998). Besides the military aircraft SU-27 and SU 30, which are exported to China, Vietnam and Irkutsk, there is no upturn expected to materialize for the Russian aerospace industry. According to the ministry of economy, the aerospace industry is going to be transformed into five or six conglomerates designing and manufacturing aircraft (Butowski, 1998).

United States:

The US aerospace industry's dominant role was established through a very positive environment. The main aircraft manufacturers Boeing, McDonnell Douglas and Lockheed were engaged in both civilian and military products. The development of new civilian products or the transformation of military in commercial aircraft was supported by a steady flow of governmental research and development money. Boeing's first successful jetliner, the B707 resulted from an evolution of the KC-135 tanker, contracted by the Pentagon. Boeings foundations for today's global supremacy in the commercial aircraft market was laid in the 1950's, when the Seattle corporation secured a string of 4,422 military orders from the Pentagon. In 1996, the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA) sales accounted for $50.6 billion, or 45% of aerospace sales (Wells, 1999).

Operating in the most developed and largest single aviation air transport market, the US airline industry assisted the manufacturers by acting as reliable and eager launch customer for new aircraft. With an initial down payment for several planes from the airlines the manufacturers could underwrite the expenses for the capital intensive projects. Another success factor of American aerospace companies was their motivation to strive continuously for innovative products despite the high financial risks involved. Boeing for example, risked the whole company when developing the B747 in the 1960's and spending $2 billion on the project, which was 212 times the value of the firm (Anonymous, 1999). Until 2005 when Airbus intends to deliver its first A3XX, a 550 to 650 seater, the B747 will be unchallenged in the 400 plus seat market. Lockheed developed the L1011 in the late 60's, a tri-jet with 250 to 400 seats capacity, but never earned money during the project life, from 1971 to 1982. The main reason for the failure of the product was that at the same time, MCD brought the DC-10, an aircraft with very similar technical characteristics as the L-1011, to the market. The demand for two nearly identical products was to low, so Lockheed never reached its break-even point. After Lockheed decided to focus on its military products, there was only MCD and Boeing left in the US civil aerospace industry. In 1997, Boeing merged with McDonnell Douglas making it an aerospace conglomerate with 238,000 employees by 1998 (Barie, 1998). Table 5 exhibits Boeing's and former McDonnell Douglas' numbers of orders and deliveries by aircraft type (Boeing, 1999).

Table 5

Boeing Commercial Jet Orders and Deliveries as of April 30, 1999

Model	Orders	Deliveries
707	1,010	1,010
717	115	0
727	1,831	1,831
737	4,264	3,361
747	1,293	1,208
757	966	859
767	865	746
777	418	208
DC10	446	446
DC8	556	556
DC9	976	976
MD11	200	187
MD80	1,191	1,167
MD90	134	104
Totals:	**14,265**	**12,659**

Source: Boeing 1998
http://www.boeing.com/commercial/orders/index.html

For 1998, Boeing reported 656 firm orders, valued $42 billion at list prices (Goldsmith, 1999). In 1999, Boeing's deliveries are expected to rise from 563 in 1998 to 620. Due to a weaker demand for wide-bodies, caused mainly by the Asian economic crises, Boeing announced a cutback in production rates for the B747 and B777 (Figure 10). A cutback from 5 to 2 B747's and from 7 to 5 B777's per month at the end of 1999 might not be enough according to an independent market analysis (Goldsmith, 1999). Boeing is phasing out all its commercial McDonnell Douglas (MCD) products beside the MD-95 program called B717 now.

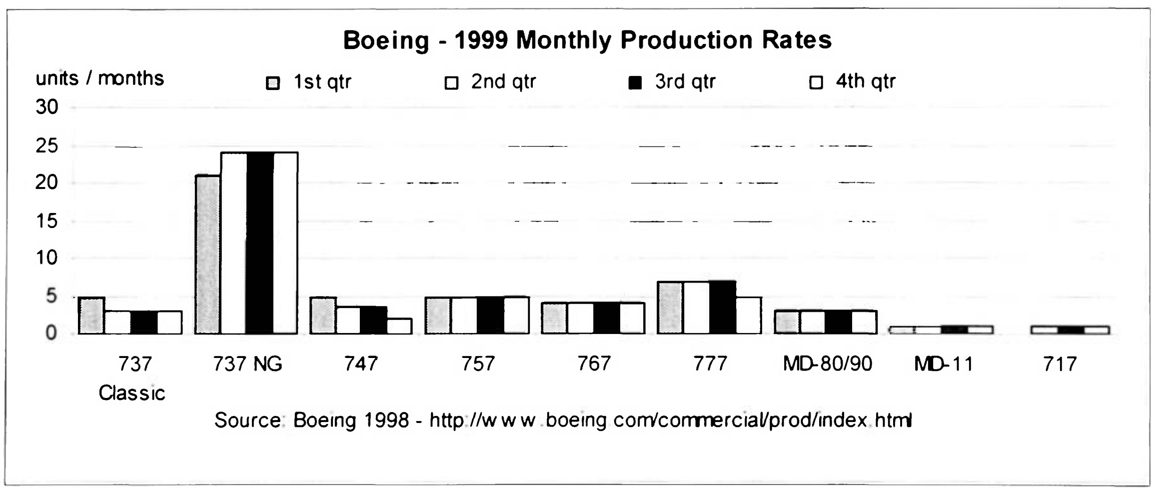


Figure 10. Boeing's Monthly Production Rates.

With just over 100 seats, the B717 rounds up Boeings product spectrum in the narrow-body twin-jet market. New Generation B737 (NG) derivatives have a seating capacity for 110 to 189 passengers. The B757, also a narrow-body jet, can be configured from 185 to 243 seats. The B767 series consists of two-aisle twinjets with a capacity of 200 to 304 seats. The two B777 models offer space for 316 to 479 passengers. Boeing's only jet, powered by more then two engines is the B747-400, which is the only aircraft able to transport more than 500 passengers (420 to 568 seats) (First Equity, 1999). Currently Boeing is exploring an altered design of the B747-400 that would increase the Aircraft's capacity from 416 to 510 seats in a three class layout, while the range would be increased to 7,800 nm (Cole, 1999).

After experiencing severe problems when increasing production rates in 1997 and 1998, mainly caused by bottlenecks in the supply chain, Boeing posted its' first loss in fifty years. Despite a huge backlog, Chairman Phil Condit conceded that for 1999 and 2000 profit margins for commercial airplanes will remain under two percent.

Figure 11 shows the 1998 List prices for Boeing's Narrow-body and Wide-body jets (Greenslet, 1998).

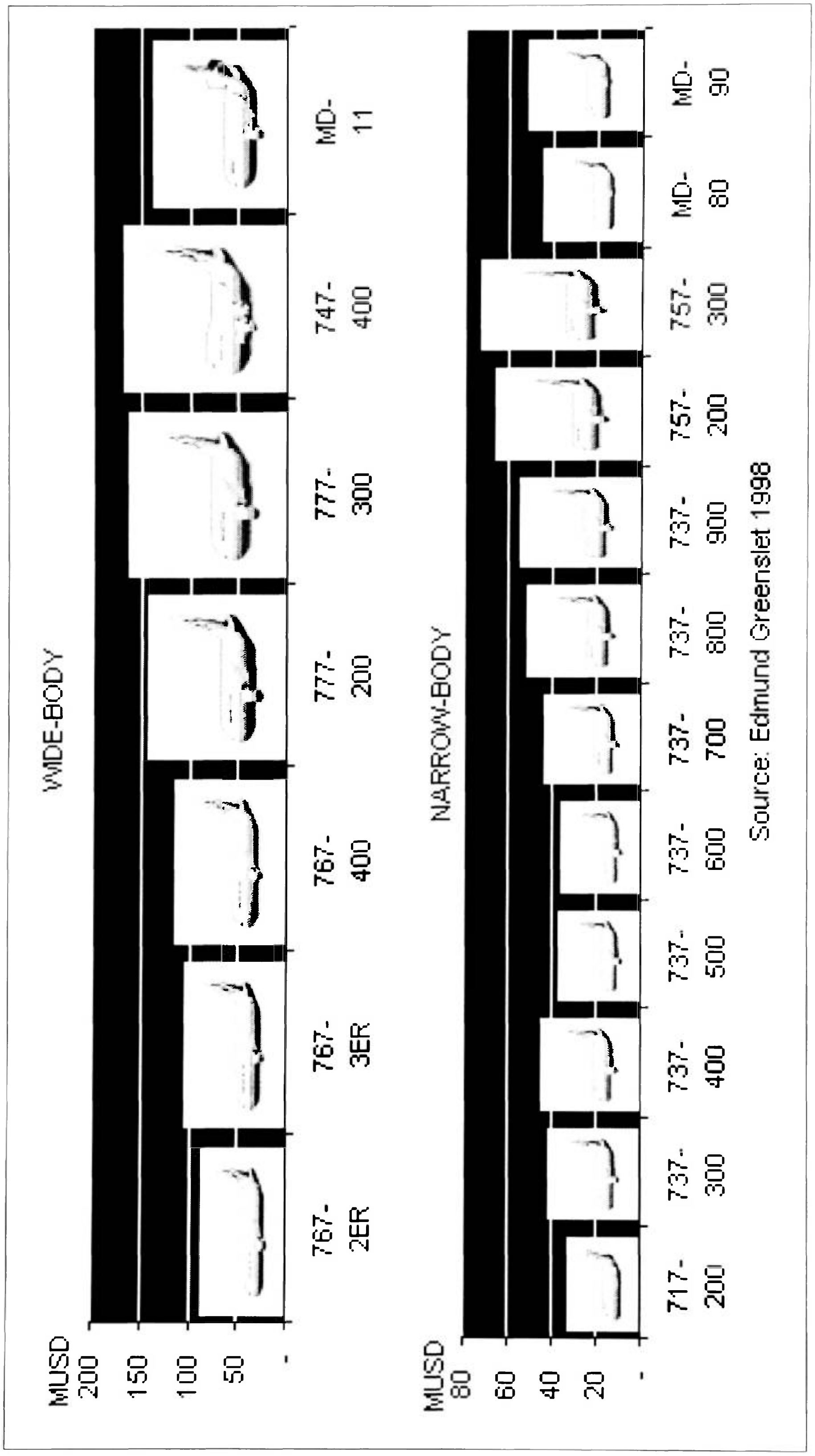
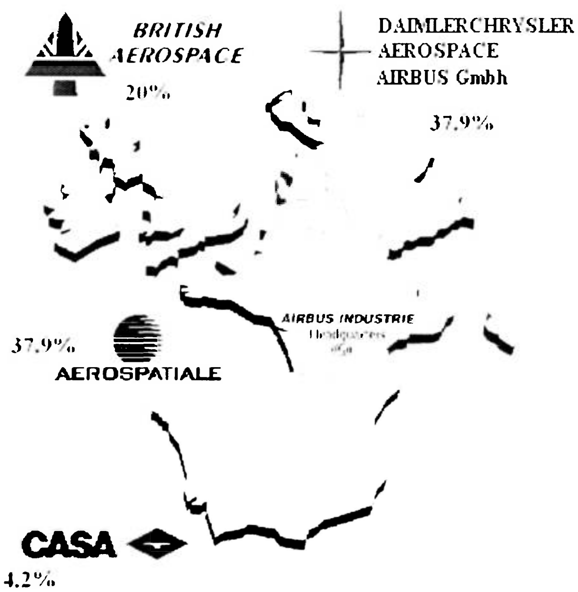


Figure 11. Boeing's 1998 List Prices.

Europe:

In Europe, the main aerospace industries consolidated during the past decades. Besides Airbus (Figure 12), only the Dutch aircraft manufacturer Fokker Aircraft BV sold civil jet aircraft. Since 1988, Fokker delivered 278 F100's, a 100 seat and 40 F70's which accommodates 70 to passengers. After Fokker went out of business in 1998, besides Airbus, there exist only regional civil aircraft manufacturers in Europe.



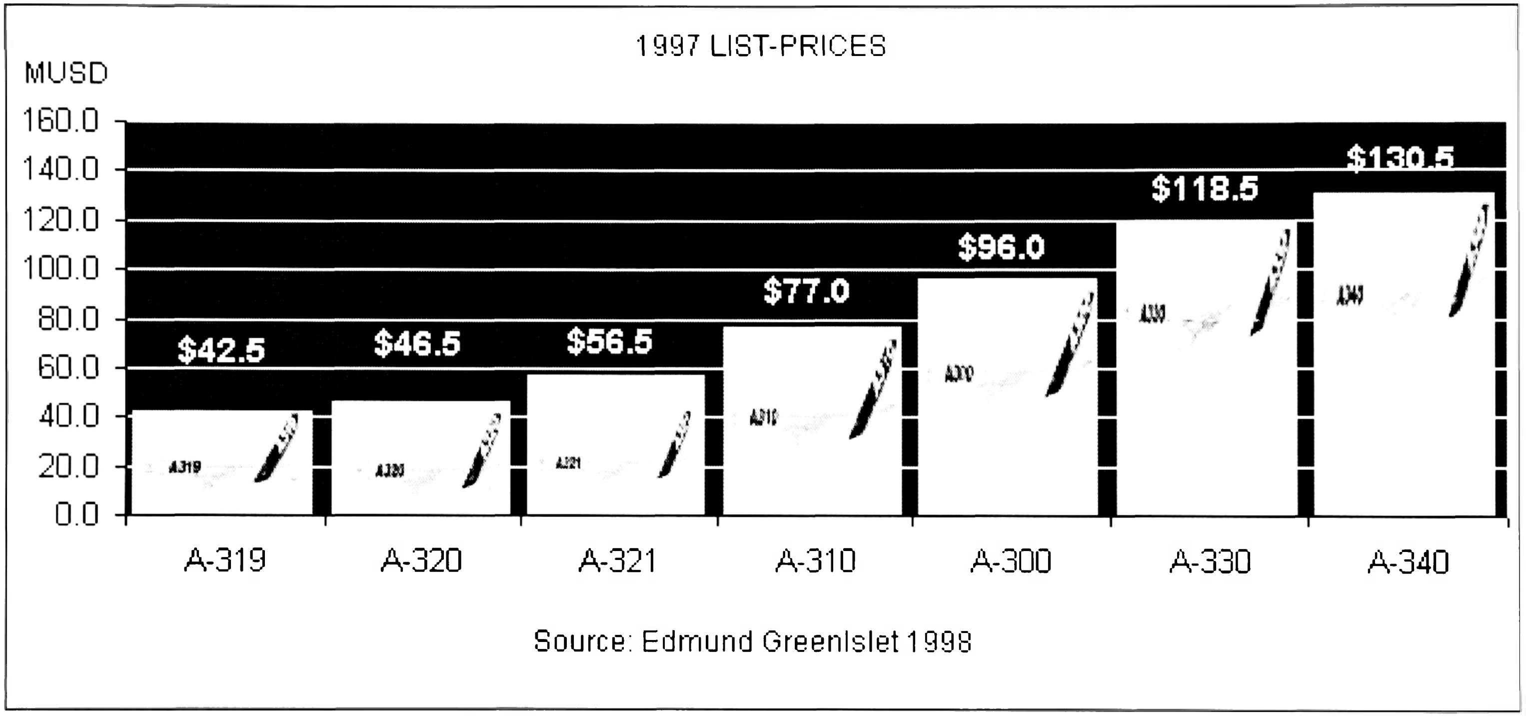
Source: Airbus 1998 - http://www.airbus.com/market.html

Figure 12. Airbus Partners.

The aerospace division of Saab (Saab 340/2000) in Sweden announced in 1998 that it would terminate its production of turboprop aircraft. The German manufacturer of regional aircraft, Dornier, merged with the American Fairchild and started to produce regional jets (328JET). British Aerospace, French Aérospitale and Italian Alenia formed the joint venture Aero International Regional (AIR), based in France. AIR sells the Avro jet and the ATR42/72 turboprop family.

In July 1967 France, Germany and Great Britain agreed to support the Airbus A300 program. In December 1970 the Airbus Industrie consortium was established. The Airbus Consortium was formed as a Groupement d'Interet Economique (GIE). Under the French legislation, all GIE partners are operating individually while sharing economic interests. While Aérospitale of France, and Daimler-Chrysler Aerospace Airbus GmbH of Germany, each have a 37.9% share, British Aerospace holds 20%, and Spain's CASA has a 4.2% share. These four partners are responsible for most of the design and all aircraft manufacture work. Airbus Industrie itself only manages and coordinates production and sales. So far the members are joint as a GIE but the long-term goal is to transform the consortium into a private corporate entity (Casamayou, 1999). Despite the delivery of 229 aircraft for a total of $13.3 billion in revenue, Airbus Industrie announced a loss of $200 million for 1998. With the addition of the 107 seater A318, to the A319, A320, A321 twinjet family, Airbus will serve the short-haul market with 100 to 185 seats. The medium range twinjet wide-bodies, A310 and A300, accommodate 210 to 251 passengers respectively. In the long-haul group, the A330 twinjet derivatives have a capacity to carry 253 to 295 passengers in three class layouts. Powered by four engines, the A340 family has a capacity of 239 to 380 seats in a three-class layout. Both, the A330 and A340 can be configured with a maximum of 440 seats. The list prices for these models are shown in Figure 13.

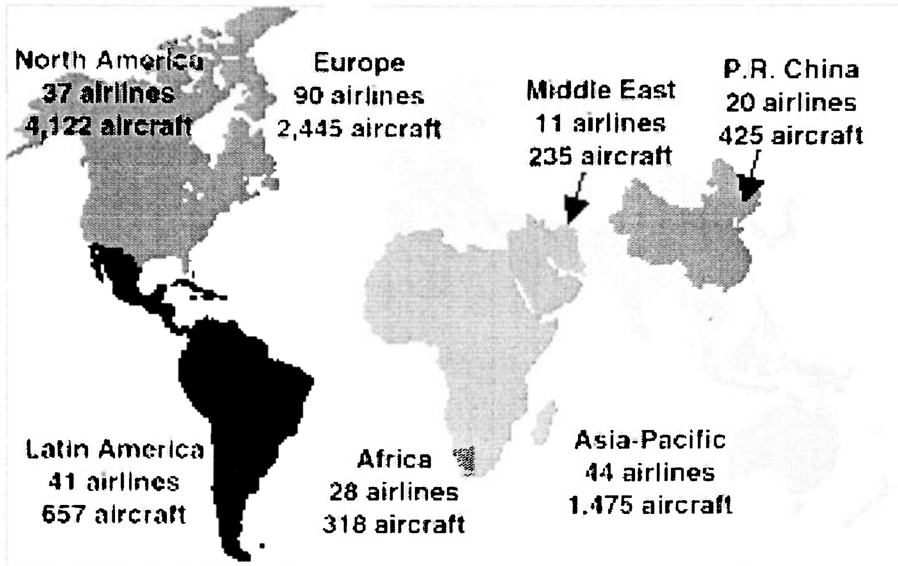
Figure 13. Airbus 1998 List-Prices.



While in the early 80's, Airbus' market-share was 15%, the goal of 50% was nearly reached in 1998. In that year, the European consortium received 556 firm orders worth $39 billion (Varley, 1999). For 1999, Airbus plans to deliver 295 aircraft; 222 of those will be narrow-bodies. The production rates will be increased in 2000 so that 317 aircraft, including 239 narrow-bodies, will be assembled. In the long run, the European consortium aims for 350 deliveries per annum (Saraco, 1999). While not launched yet, the A3XX, a jetliner with two passenger decks for the full length of the fuselage is scheduled to enter service in 2005 (van der Walt, 1999). In a three-class configuration, the new aircraft will accommodate 555 passengers. The new price for an A3XX will be between $180 and $200 million. Critics argue that there is not enough demand for such an aircraft to recover development costs, and that it will be hard for airlines to generate enough revenue on price elastic longhaul routes to earn a sufficient return on such a high investment (Holloway, 1999).

2.4.2 Demand

Demand for new aircraft is determined by two factors. One factor is the airlines' expectations of traffic growth and their need for additional capacity. The second factor is the need for replacement of old aircraft. Old aircraft become either uneconomical to be operated or prohibited to be operated by environmental legislation.



Source: Airbus 1998 http://www.airbus.com/market.html

Figure 14. World-Wide Aircraft and Airline Distribution.

Excluding the CIS states, in 1998 the 217 world major airlines were operating 9677 aircraft with more than 70 seats. The distribution of these aircraft can be seen in Figure 14. The biggest two markets are North America and Europe, followed closely by the Asia-Pacific Region (Boeing 1999).

Two trends are characterizing the Airline industry at the end of the 20th century. Number one is a continuously growing popularity of the hub and spoke system. Today hubbing is used by nearly every airline in order to rationalize route networks and improve the quality of service, since even small communities can be served economically at reasonable fares. The second trend is consolidation and the formation of international strategic alliances.

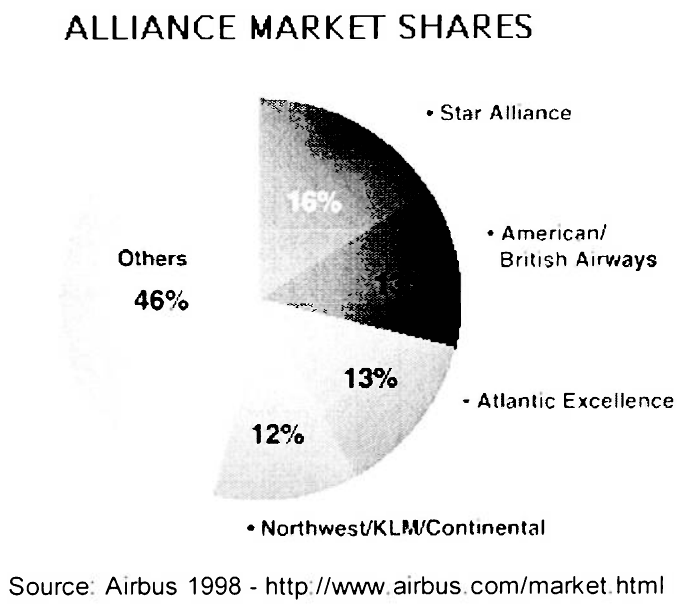


Figure 15. Alliances Market-share.

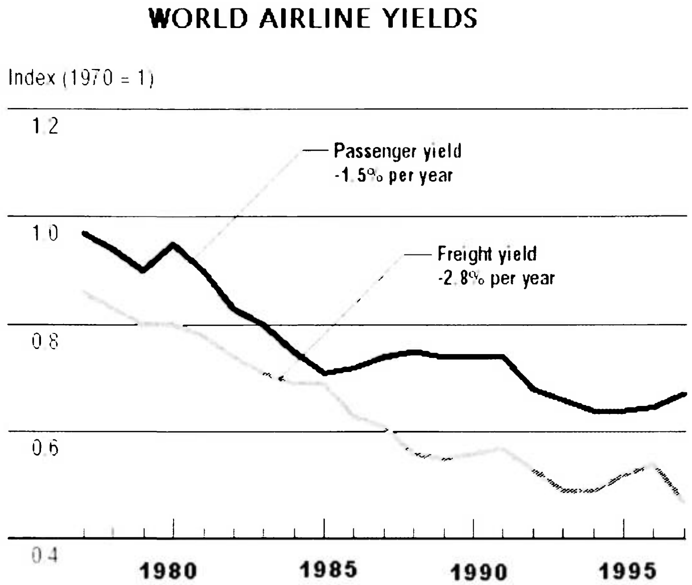
Currently just four major global alliances are carrying about 60% of all world passengers (Figure 15). The three main reasons for the airline industry to form alliances are to provide the customer with one global route network, seamless travel and to increase profits. Profits can be increased due to the fact of increased economies of scope, density and scale and common resource allocation while simultaneously the extended network and frequencies can stimulate demand and result finally in higher load-factors (Feldman, 1998). It is expected that alliance partners will also seek to exploit their combined buying power by rationalizing their purchases of goods and services and of aircraft. As a result there might develop oligopoly concentration on the aircraft demand side similar to that on the supply side. Delta, Singapore Airlines and Swissair for example set up a joint purchasing operation in 1996. As part of its Mercurious program KLM purchased aircraft in bulk with some of its partners. Another example is the joint purchase of A330 by Swissair, Austrian and Sabena (Holloway, 1998).

Besides operating in an healthy economic environment and exploiting the advantages of liberalization and alliances, the development of highly sophisticated yield management systems contributed highly to the success of most airlines in the late 90's. Revenues and load factors increased after the recession at the beginning of this decade (Figure 16 and Figure 18, Boeing, 1999). Despite high profits during cyclical upturns, overall industry earnings have been poor (Holloway, 1998).

Source: Boeing 1998 - http://www.boeing.com/commercial/cmo/2si02.html#revenue

Figure 16. Historic Load-Factors by Region.

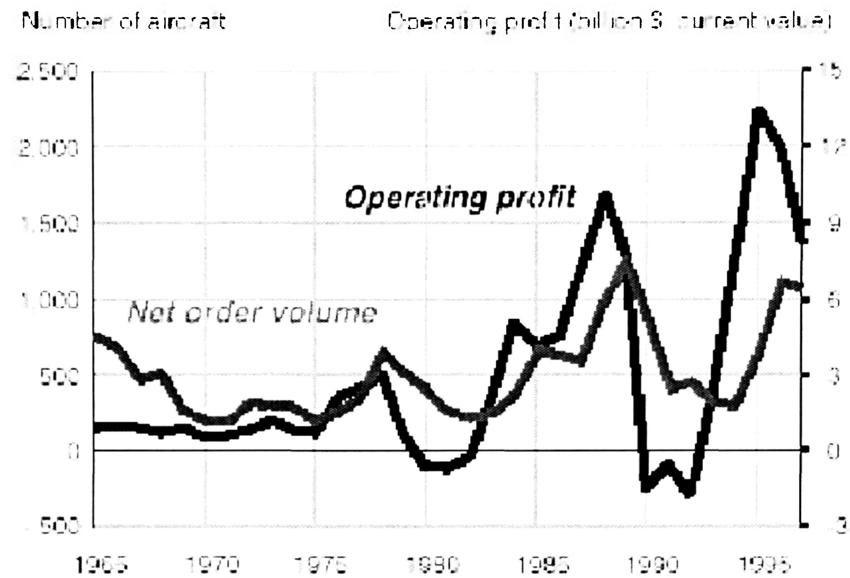
Increased competition resulted in higher productivity but also in generally decreasing yields (Figure 17).



Source: Airbus - http://www.airbus.com/market.html

Figure 17. History of Passenger- and Cargo-Yields.

The cyclical growth of the industry is explained by two factors. One is the sensitivity of demand to fluctuations in the economic environment, the business cycle. The second factor is the lead-time for new aircraft. In the past airlines ordered too many aircraft during boom periods and needed to take delivery when the demand slowed down. The result was an increase in capacity in an already saturated market (Holloway, 1998). Figure 18 exhibits how the order backlog decreases only slowly during downturns.



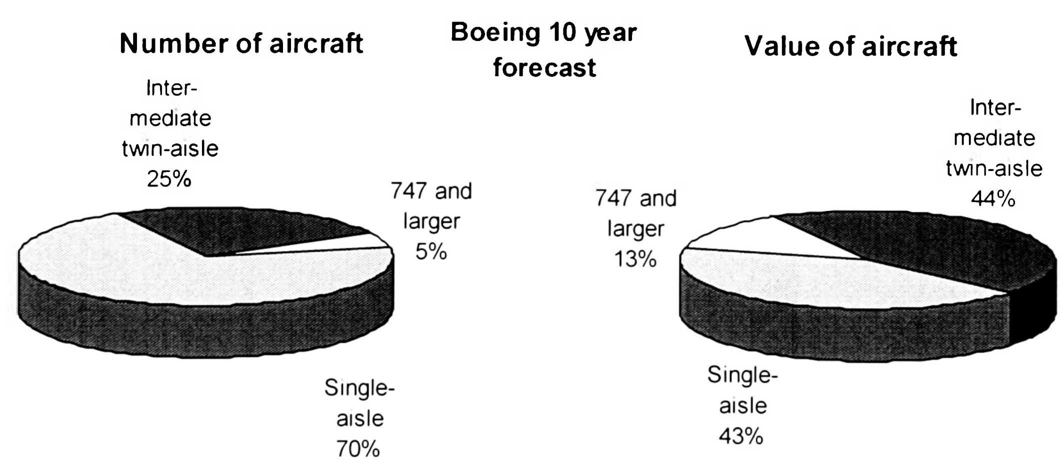
Source: Airbus - http://www.airbus.com/market.html

Figure 18. Net Order Volume and Operating Profit.

As a result of over capacity yields dropped and at the low operating margins prevalent in the industry, operating cost for most airlines were higher than revenues. During 1990 and 1993 industry wide net losses accumulated to more than $15 billion (Holloway, 1998).

Since many carriers became privatized or more financially accountable during the 1990's, airline decisions are now driven more by commercial other than political concepts (Holloway, 1998). Airlines are now more concerned with life cycle costs. Manufacturers need to prove that new technology offers cost or revenue advantages. The airlines use the revenue-earning potential as a reference to value, not the manufacturers cost-plus formula (Holloway, 1998). British Airways for example is requiring a significant reduction in seat-mile cost compared to the B747-400 for the A3XX, in order to be interested in the new aircraft (Woolsey, 1998).

The demand for commercial jet aircraft with more that 70 seats predicted by Boeing and Airbus is similar. For the next 20 years both manufacturer predict traffic to grow by five percent. As a result Airbus foresees demand for 13,600 new aircraft while Boeing foresees demand for 17,300 new aircraft. On average, these numbers reflect annual deliveries of 680 and 865 aircraft respectively. Boeing predicts the composition of the world fleet to be 71% single-aisle airplanes, 22% intermediate-size airplanes and 7% 747-size or larger airplanes. Figure 19 shows that the total value of single-aisle aircraft is relatively low compared to the 70% share of total deliveries. This explains the importance of wide-body orders for the manufacturers.



Boeing, 1999 - http://www.boeing.com/commercial/cmo/index.html

Figure 19. Comparison of Aircraft Values and Units Produced.

Leasing Industry:

Commercial aircraft leasing has strong growth rates, as airlines look for alternative means of financing. Since deregulation in 1978, the aircraft has not only grown in size but also in variety of services offered by aircraft financiers. Technological advancement as well as rising safety standards caused capital expenditures to rise. "Airlines can now juggle investment options by managing their assets through mixing finance formulae which use traditional loans as well as finance leasing and operating leasing" (Wagland, 1999). It is estimated that about 25% of the 1999 airline fleet is operating under operating lease agreements. While in 1992, 50% of aircraft were owned by the airlines, this number decreased to 40% in 1995. Then, 37% of the world airline fleet was financed by finance lease agreements and 23% under operating lese agreements (Wagland, 1999). The future of the leasing industry is characterized by the airlines desire to increase financial flexibility, benefits of tax advantages, and limit risk. Table 6 summarizes the reasons for increased popularity of aircraft leasing (Holden, 1998).

Table 6

Drivers of Leasing Popularity:

Airline Privatization focusing attention on Balance Sheets
Competition increases need for Flexibility and Quick Response to Market Opportunities
Low Rates of New Aircraft Price Escalation reduces Economic Attraction of Ownership
Long Term Fleet Mix difficult to predict as Markets and Products Change
Leasing no longer seen as The Expansive Solution of Last Resort but rather as One Component of Overall Financing

Summary:

With a monopoly in the 400 plus seat market and access to a much bigger customer base than Airbus, Boeing is ranked as the number one aircraft manufacturer. With revenues approximately four times as high as Airbus', and a wider product range which includes military and space products, Boeing will most likely keep its leading position in the industry (Holloway, 1998). By implementing a common management information system and by restructuring the organization, Boeing is trying to prevent the problems experienced in the late 90's from happening again. While fighting for market-share, the challenge for both manufacturers is to "find ways to continually improve their ability to flexibly expand and contract production capacity to meet the needs of a very cyclical business" (McClehanen, 1998).

On the demand side, the manufacturers predict a healthy growth, but the danger of over capacity needs to be recognized since lead times become reduced only in little increments. Analysts believe that the high production rates will not be reduced early enough in order to prevent capacity from outgrowing seat demand (Velocci, 1998). Despite a continuing Asian Crisis, airlines did not reduce their orders significantly. The airline industry remains optimistic that the traffic growth will be sufficient to fill all the new sets added to their fleets.

In 1998 about 200 aircraft were retired. Increasing retirements for the next five years seem likely as nearly 2,500 aircraft will reach 30 years of age or older. (CL/PK, 1998). Traffic growth was about 6% to 8% annually since 1996 and is expected to continue in this range. For 1999 and 2000 up to 1,000 aircraft will be delivered per year.

3 Aircraft appraising

3.1 Why is it important to forecast aircraft values?

Future value forecasting is important:

- For airlines when they make investment decisions to buy aircraft
- For non-airline Investors such as lessors
- For financiers if the Investor defaults and the aircraft functions as collateral
- Leasing industry

The need for accurate aircraft value forecast emerged particularly with the growing leasing industry and the operating lease boom during the 1980's. Between 1986 and 1996 the number of airlines leasing all their fleet increased by 465% to 214. In 1998 about 23% of the world's commercial fleet is operated under similar operating lease agreements (Holden, 1998). The spreading inability of second tier airlines to finance directly the aircraft needed to accommodate growth and replacement and flag carrier's need for flexibility will result in further expansions of the leasing market (Wells, 1993). Besides differences between national leasing laws, the industry distinguishes mainly between financial and operational leases. The airline industry uses different financial tools in order to expand or renew their capital-intensive fleets. Besides buying aircraft with internally generated funds, airlines often choose between different lending respectively leasing possibilities.

Asset based financing:

If a loan or a financial lease is asset based, the amortization of principal debt outstanding is planned to be always lower than the expected aircraft value. The asset based financing is also known as non-title based financing. It includes generally a first priority mortgage over the aircraft being financed, a security assignment over the lease payments if the borrower leases out the aircraft to an operator, and other protections and assignments of aircraft liability insurances. First priority mortgages need to be defined carefully because of accessibility of the aircraft and ensuring priority over any local charges, costs and related liens. In the case of an obligors default the lender has to realize the value of the aircraft in order to be cured in full. To evaluate the risk the lender is exposed to, he needs to know the expected future value of the aircraft. The more accurate the aircraft's value can be predicted the higher the confidence and the lower the risk for the lender. The younger and the more popular an airframe engine combination along with the higher the market penetration, the easier it is to re-market the aircraft. Also, the steadier the value of the asset is. However, the market conditions are mainly determined by the imbalance of the demand and supply of capacity and should be considered along with the accuracy anticipated in order to evaluate the aircraft's future value.

If a loan is obligor-based and a default occurs, the lender is entitled to other predetermined sources of capital, for example the proceeds from selling other assets, cash collaterals, or letters of credit as the underlying aircraft's value would be too low to compensate for the forgone repayments.

Finance leases:

A financial lease is generally the same as an aircraft acquisition financed by a secured loan. Similar to a secured loan, the lessee acquires the operational risks and rewards of ownership throughout a substantial part of the aircraft's economic life. The main difference between purchasing and leasing an aircraft is that with the acquisition of the aircraft, the title is transferred directly to the buyer whereas under a financial lease, title remains with the lessor or lender. If the aircraft is leased, no substantial advance payments are necessary and the acquisition of the aircraft entitles the lessor to take advantage of tax shelters. Receiving sufficient rental payments over the life of the lease, the lessor recovers the cost of the aircraft plus an additional return on its investment. Under a full payout lease, which is typical for financial leases, the lessee amortizes down the principal either by sufficient monthly rates or monthly rates with an additional final balloon payment. In both cases, the lessee receives title to the aircraft at termination of the lease. Sometimes a lease is initially set up as a non full-payout vehicle subsequently extended to a full-payout lease. With the transfer of the title, the operator becomes exposed to the residual value risk if the aircraft is not technically or economically obsolete at the end of the lease period. Depending on the jurisdiction, an airline often is not required to keep a leased aircraft on the balance sheet as a liability but as an "asset under capital lease"

Since the long-term lease payments and tax shelters compensate the lessor, he is barely exposed to residual asset value risk. As the asset is not the generator of the return, the lessor concentrates mainly on the credit rating to evaluate an airline. However, should the lessee default, the lessor holds title to the aircraft and is entitled to reimbursement by selling or repossessing the asset. To predict and evaluate the risk the lessor is exposed to, he needs to know the future values of the underlying aircraft.

Financial leases are considered long-term vehicles binding the contract partners for 10 to 12 years. An exception is with US leveraged leases, which can run for over 20 years. Despite the longer period of the lease, the payments of finance leases are generally lower than those of operating leases. The combination of tax benefits and marginal asset risk enables lessors to offer financial leases at favorable terms.

Being charged lower rentals the lessee also profits from the lessor's tax benefits of aircraft ownership. Often deals are closed between lessees and lessors in different tax jurisdictions, so that both parties are permitted to depreciate the aircraft for tax purposes. As a results the cost of leasing the aircraft can be kept down even more.

Generally financial leases cannot be canceled, however early termination clauses can be attached to the contracts. By paying relatively low penalties in order to compensate the lessors for the foregone payments, airlines find financial leases to be vehicles nearly as flexible as operating leases.

Operating leases:

The operating lease is a non-payout tool, which offers the lessee the opportunity of high flexibility regarding the time frame of the lease contract. A medium term lease period is considerably shorter than the finance lease and runs usually over 3 to 7 years. Whereas the economic life of modern aircraft easily exceeds 25 years, the operating lease enables the airline to react promptly to variations in the market. Not only the short lease periods but particularly lead times for new aircraft between 9 to 18 month, if production slots are available, make the operating lease attractive for short-term fleet planning purposes. Sometimes a sub-leasing option gives the airline additional flexibility. An acquisition or finance lease would bind the airline much longer to the asset. As an "off-balance sheet" item, the operating lease does not influence the airline's leverage. The rental payments, which are generally due monthly, are booked as operational expenses in contrast to a liability.

While holding title of the aircraft the lessor is permitted to exploit the tax benefits of ownership, but he is also exposed to all the economic risk attributable to aircraft ownership. Exposed to the financial and asset value risk due to the long term financial commitment of aircraft ownership, the lessor does not receive sufficient payments during a single operating lease period to amortize his expenses and, thus, after expiration of a lease contract he needs to re-market the aircraft. Selling or re-leasing the aircraft, the lessor each time faces new marked conditions determining the return on the next deal. New lease payments or the selling price of a returned aircraft depend mainly on the demand and supply in the market. High risk involved in this form of short-term lending justifies the higher payments for operating leases. To be able to offer sufficient aircraft with short lead times an operating lessor needs to order new aircraft well in advance. Thereby, he is also exposed to a high risk since he has to predict the number and type of aircraft the market will demand in the future. Bulk purchases of aircraft on the one hand represent a risk, the lessor is exposed to while on the other hand a lessor can take advantage of significant price discounts. For example, ILFC took delivery of 60 new aircraft in 1997 In 1996, ILFC took delivery of 15% of Boeings' and Airbus' total production (Plueger, 1998). Getting high discounts combined with high credit ratings, which decrease the cost of capital, lessors can provide the airline industry with aircraft at reasonable rental payments, even when charging them for the high risk. While the airline is not exposed to the residual value risk it forgoes any equity upside opportunity in the aircraft future value. Thus, being able to predict future aircraft values accurately, reduces the risk and bears an enormous profit potential.

The re-marketing of aircraft requires special skills from operating lessors. They need not only a great deal of financial expertise but also excellent asset knowledge, because they must be able to evaluate technical and maintenance conditions of aircraft in order to check the compliance of return conditions at the end of each lease. Furthermore, they need to process legal knowledge to the multitude of different contracts varying with its customers. In regard to future deals and the re-marketing of an aircraft after a lease expires an excellent reputation is required in order to augment contacts. As such, an in depth understanding of market trends is a major prerequisite for a successful operation. A continuing identification of current and future trends in the aviation industry is essential to develop traffic and aircraft value forecasts. The cyclical character of the airline industry, which will be discussed in detail later, mainly determines the trends in the market.

3.2 Factors affecting aircraft values

3.2.1 Economic depreciation

Similar to other industrial products, an aircraft is depreciating over time. Assets depreciate constantly (i.e. straight-line method), if repairs and other operating costs or profits, do not vary and the cost of capital rate is negligible (William, 1992). These prerequisites are not given in case of an aircraft. There are two reasons responsible for the inconsistent depreciation of aircraft. First, an aircraft deteriorates over its years of operation, which can sometimes last as long as 25 years. Depending on flight hours and landing and take-off cycles, the cost of maintenance and correspondingly the downtime is increasing. The aircraft will also loose operational efficiency due to additional drag and weight. Second the competition from new aircraft with modern technology, as two men cockpits, fly by wire, or more fuel-efficient engines depreciates an aircraft's value faster. The increase in direct and relative operating costs reduces the cash flow generating capacity of the aging aircraft. Utilization of old aircraft is decreasing not only because of longer maintenance downtimes but also because airlines prefer a higher utilization of new equipment at lower operating cost.

Increasing operating costs have a major impact on the theoretical value of an aircraft, called base value. The base value defined as Reference Value (RV) at Credit Lyonnais/PK Airfinance (CL/PK), represents the net present value of an aircraft's future cash flow generating potential. Increasing operating cost and lower utilization reduce the net cash flows and thereby the value of aging aircraft. Even though the aircraft's life is theoretically not limited, the increasing operating cost will at one point in time exceed the revenue generating capacity and thereby determine the end of the aircraft's economical life. From a technical point of view only environmental restrictions or heavy accidents lead to aircraft being withdrawn from operation. Thus aircraft often do not only stay in service for the 25 years they might have been designed for, but possibly for 30 years, if load factors are high enough to generate profits even at higher operating costs compared to younger equipment. The following graph (Figure 20) presents the theoretical straight-line depreciation and the real asymptotic depreciation of aircraft values.

Source: Hallerstrom 1998

Figure 20. Aircraft Value Depreciation Patterns.

The theoretical depreciation is calculated with constant cash flows and a base life of about 25 years, resulting in a straight-line depreciation. But in reality, operational cost increase at the end of the prime life resulting in declining cash flows after 15-18 years. Since most of the aircraft are operated longer than the initially planned 25 years assumed for the straight-line method, the real depreciation line is extended until 30 years. This line is descending asymptotically towards zero because the increasing operational costs reduce the cash flow generating potential. Despite the increasing operational costs, the extension of the economical life over the base-life generates additional revenues. This explains why real aircraft values as a percentage of the new price stay higher after passing the prime life than the straight-line values.

The importance of the economic life and of the cash flow generating capacity of the aircraft should be understood now. The real depreciation curve or reference value curve derived by CL/PK from fitting trend-lines in scatters of historical resale values can be expressed as a function of time. The reference value used and developed by CL/PK is only a theoretical figure, derived from historical experience and independent of technical aircraft data.

Other models used to predict the base values of aircraft, usually applying aircraft specific variables, are much more extensive and complicated. Since a lot of assumptions are necessary to predict airline operating cost and revenues the accuracy of these techniques needs to be analyzed. Using industry averages bears a high potential of uncertainty, since cost structures of airlines are very different and not transparent. Too many unknown variables need to be anticipated in order to find the profit generating potential over a specific aircraft's economical life. Besides inflation, labor cost, exchange rates, load factors, and airfares need to be estimated for one to three decades. Everybody must agree that this task bears a very high degree of uncertainty. Looking more intensively on only one of the variables, the fuel price (Figure 21), which has a substantial impact on aircrafts' operating costs, we find a high volatility making accurate long-term predictions elusive.

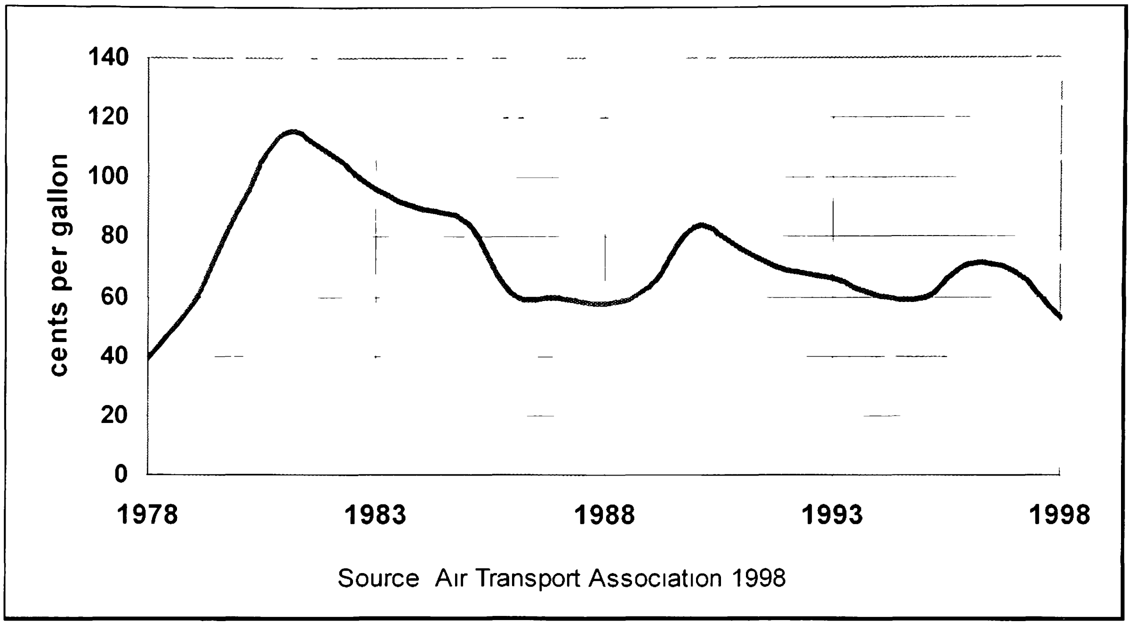


Figure 21. Historical Jet Fuel Cost.

The following CL/PK formula (Equation 13 and Equation 14) require only two variables to be predicted, the prime life and the base life. This is an easier approach to calculate the reference value. Since the formula is derived from historical experience, the reference value is believed to be more accurate than the cash flow generating approach used by most appraisers.

for $t < t_p$: $$RV(t) = RV_0(1 - \frac{t}{t_b})$$ (13)

for $t > t_p$: $$RV(t) = RV_0 \times (1 - \frac{t_p}{t_b}) \times e^{\frac{t_p}{t_b - t_p}} \times e^{\frac{-t}{t_b - t_p}}$$ (14)

Where $RV(t)$ is the constant dollar reference value at time t, RV_0 is the average new price of the aircraft, t_p is the prime life, and t_b is the base life. This constant dollar reference value (RV) is subsequently grossed up for historical inflation and expected future inflation to return the inflation adjusted reference value (IARV). This value is the equivalent to the base value representing an aircraft's value in a market with demand and supply in equilibrium. The IARV is the foundation used to calculate the future values of aircraft by the CL/PK SAFE (Statistical Aircraft Financing Evaluation) model, explained in paragraph 4.1.3. In the final analysis, the SAFE reference value will be compared to the value resulting from a NPV model designed for the B737-300.

3.2.2 External and internal factors

The value of an aircraft depends on internal and external factors. External factors are not related to the aircraft itself. Since aircraft are traded in one global market, political, economical and environmental developments determine the basic market conditions. In Figure 22, the summary of aircraft value determinants can be found.

AIRCRAFT VALUE DETERMINANTS

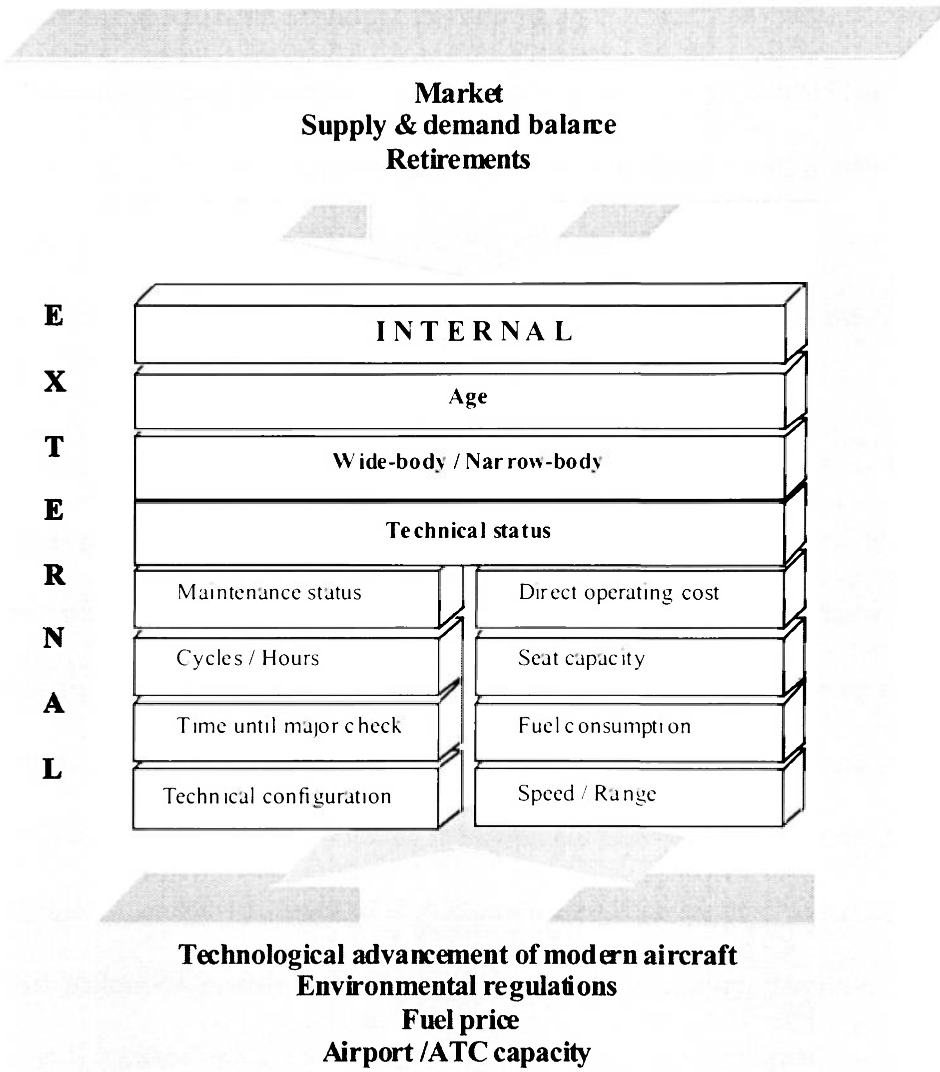


Figure 22. Internal and External Aircraft Value Determinants.

The main force driving the airline industry either up or down is the supply and demand ratio of seat capacity. The imbalance is created by the following simplified chain reaction. Airlines order new aircraft when load-factors are up and the business is prospering. But due to minimum lead times of 12 to 18 months, most airlines take delivery of the equipment when the market is already saturated. The additional seat capacity results in a surplus of supply and according to general economical rule prices, will decline when demand becomes exceeded by supply. Lower yields result in airlines retiring old and uneconomical aircraft along with hesitating to invest in new aircraft. Finally, the demand for air traffic starts to outgrow the seat capacity. While the industry earns big profits, the next down cycle is already launched, since additional capacity will be delivered too late again.

With the growing and decreasing demand for seat capacity the price for aircraft also swings up or down. High demand for capacity results in a high demand and high prices for used aircraft, since these can be obtained much faster. A further external factor, the general economic situation, represented by the world's Gross Domestic Product (GDP) growth, is the main factor determining the demand for business and leisure air travel. GDP growth combined with the development of more efficient new aircraft, fuel price alterations, and environmental regulation lead to changes in airline capacity. High fuel prices make newer, more efficient equipment very attractive. Airport and Air Traffic Control (ATC) infrastructure constraints might influence demand for bigger aircraft because certain routes do not have enough slots available to operate medium sized aircraft at high frequencies. As soon as the Stage II ban is implemented, environmental regulations will cause more retirement of the older aircraft. Depending on these external factors, the values for certain aircraft categories or types deviate more or less from their base values.

Internal factors are directly related to the aircraft's specifications such as age, size and technical status. All three factors have major influence on the aircraft value, but depend also on the external factors. For example old wide-bodied aircraft are sought after if there is a capacity shortage and fuel cost are not too high. Technological progress reducing operating cost of new aircraft in combination with environmental regulations and high fuel prices would have dampening effects on the values of old equipment. Old aircraft are retired when load-factors are too low to generate revenues higher than operating costs. Operating costs mainly determined by fuel consumption, range, seat capacity and maintenance necessaries as well as by fees for airports, ATC or insurance define in dependence to the market situation the end of an aircraft's economical life. Higher operating cost in general result in lower aircraft values.

Besides type related factors, there are also aircraft specific characteristics determining an aircraft's value. Maintenance quality and remaining time toward the next major check, cycle and hours an aircraft was utilized along with technical configuration are considered in an aircraft specific evaluation process. High quality documented maintenance programs and higher specifications as extended range (ER) or extended over water operation (ETOPS) can increase the value of an individual aircraft. A low amount of flight hours and a high flight hour to cycle ratio, explained in the next chapter, are also desirable characteristics in order to achieve high selling proceeds. The longer the time before the next major check, which is in general very expensive, is due the higher the value. Further subjects to be considered when evaluating aircraft are discussed in the following chapters.

3.2.3 Cyclical effects

Air traffic is generally measured in revenue passenger miles (RPM) flown per year. Looking at the historical development of RPM growth, the cyclical pattern, which characterizes the aviation industry can be found Figure 23.

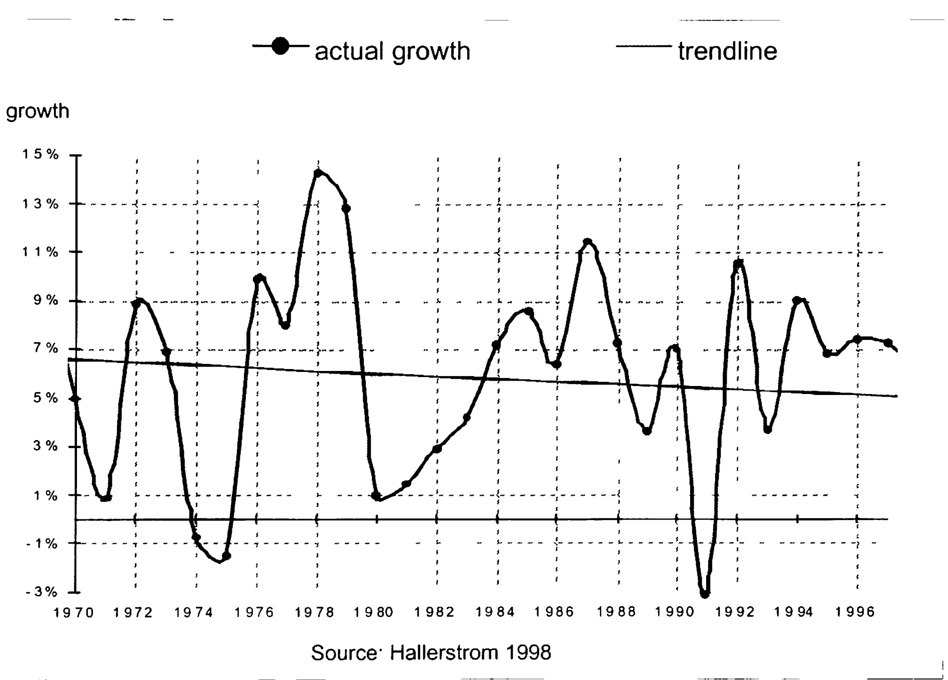


Figure 23. Percentage World-Wide Annual Traffic Growth (RPM).

But why is the traffic growth so volatile? The answer lies in the high correlation of air traffic with the world's GDP (van Donselaar, 1998). Since 1970, world GDP officially has grown continuously with three recessions slowing down economic expansion and resulting in boom and economic slump periods. The slow down in GDP growth lead to reduced business travel as well as to reduced leisure travel due to lower disposable incomes. Simultaneously, the increase of the oil-prices during these recessions resulted in higher fares and further reductions of air traffic.

A small proportion of the RPM growth is explained by generally decreasing fares. Airfares were on average declining over the last three decades because the continuing trends of international deregulation increased competition. The decline of costs for air transportation could be realized because of higher productivity and lately developed sophisticated yield management systems. Competition was the main driving force for cost reductions.

A volatile RPM growth requires airlines to constantly adjust their capacity to changing market conditions. The airline industry on the one hand needs new aircraft if it wants to accommodate traffic growth and on the other hand must retire old equipment in case of surplus seat capacity. The difficult task is to foresee the cycles of capacity surplus and capacity shortage. To cover the cost of aircraft ownership and operation, airlines fleet planning departments must choose aircraft meeting the capacity requirements of different routes very accurately in order to ensure high load factors. Without achieving high load-factors, airlines can not be profitable. In the short run, airline capacity is fixed due to long lead times from the manufacturers. Any capacity expansion has to be planned well in advance, because aircraft manufacturers need to design individual production schemes for each customer and need to coordinate the supply chains. There are various reasons why aircraft production rates are inflexible. The extensive planning, manufacturing, and assembling process results in lead times of 10 to 18 month assuming open production slots (Velocci, 1996).

Comparing Figure 23 and Figure 24, the delay in seat growth, resulting from the inflexible production rates, relative to traffic growth can be seen. While traffic was down in 1991 and 1993, it took the manufacturer two more years to adjust their production rates to a minimum level in 1995. According to Figure 23, traffic was increasing already since 1993. Hence, the creation of the next imbalance was foreseeable. The capacity supply and demand imbalance can be explained by the airline's hesitation to order before air-traffic peaks and the aircraft manufacturer's inflexible production rates.

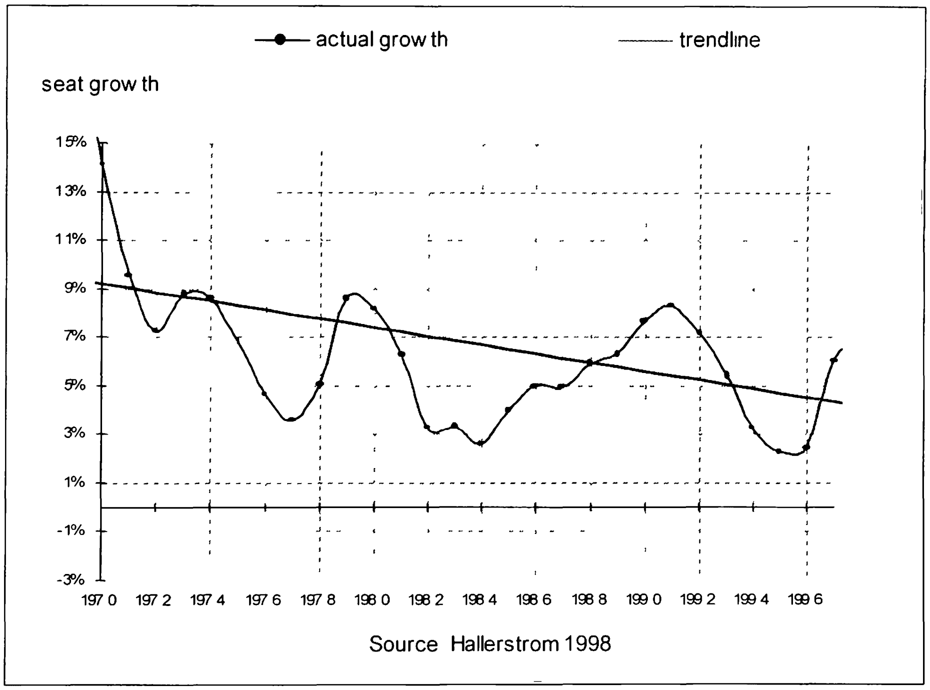


Figure 24. Annual Percentage Capacity Growth (in Seats Worldwide).

The past has proved that airlines seem to miss the foresight to anticipate market-trends, regarding the cycles. In order to adjust for capacity constraints airlines start ordering aircraft not before but during traffic peaks. As could already be seen in the late eighties, the continuing trend of traffic growth and high load factors for several years, resulting in strong earnings for the whole airline industry was recognized to late. Hesitation to order new aircraft in advance lead to a big capacity shortages at the peak of the traffic growth. Only then, after earning high profits, airlines ordered new aircraft in order to keep up or expand their market-share, believing that traffic will continue to grow. Since new equipment was not available in the short run the order backlog grew and simultaneously the demand and thereby the values of used aircraft rose. Motivated by big order backlogs and fear of loosing market-share both, Boeing and Airbus boosted their production rates. While old and new equipment was extensively utilized the delivery of new aircraft combined with reductions in traffic growth in the future will probably result in diminishing yields for the airlines similar to the painful experience in the early nineties. However, it is expected that the decline in traffic caused by the Asian financial crisis will be more moderate than the extreme reductions in air traffic during the gulf war. Then the combination of declining traffic and the delivery of aircraft ordered during the peak resulted in an extreme surplus in capacity and load-factors dropping heavily. On top of the reduced revenues airlines suffered from fuel price rising from 1988 to 1991. By reducing the fares airlines tried to keep up load factors but they were incapable of stopping the revenue streams to decrease. The combination of rising fuel prices and low load-factors lead to retirements and parking of old equipment. More than 1,000 aircraft, including brand new B747s, representing about 10% of the world's commercial fleet were idle (Will they ever fly again, 1992). Because of barely any demand for old aircraft, their values dropped deeply especially for wide-bodies. For example, a 1972 delivered DC-10-30 appraised at $32.5 million in 1991 was traded for $15 million in 1993 (Airclaims, 1998). After capacity was adjusted and airlines improved their cost structures, the industry experienced a boom in the late nineties. In 1997 and 1998 many airlines posted record earnings (Flint, 1998).

It is expected that a new downturn started simultaneous with the Asian Crises in 1998. Will this downturn have similar disastrous consequences for the airline industry as in the early nineties? Comparing the order and delivery ratio could help to answer this question. In 1989 orders accumulated to 1600 aircraft up from 600 in 1987. In 1991 production rates broke the 800 mark, an all time high. As a result of flooding the saturated market with surplus capacity, industry's losses exceeded the accumulated earnings of many previous years. Despite this experience just recovered from, the 1999 trends in the aviation industry are very similar to the beginning of the last downturn. In 1991 Boeing and Airbus delivered 605 and 163 aircraft respectively. For 1999 Boeing has planned to boast its production rates to deliver 585 Aircraft. This figure does not include a small number of former McDonnell Douglas aircraft types. Combined with an estimated output of 260 Airbus aircraft, a total of about 850 aircraft will be delivered in 1999 (Greenslet, 1998). Boeing has adjusted its production plan already slightly downward in order to adjust to the slow down of traffic growth due to the Asian crisis. The B747 monthly production rate will be reduced from 5 to 3.5 and the B777 production rate will fall from 7 to 5 aircraft per month (Boeing, 1999). While Asia is not believed to recover fast it is doubtful that the market can absorb all the new seats. As a consequence a new downturn is expected and aircraft values are supposed to fall again. According to the Airline Monitor Commercial Aircraft Market Forecast, the capacity surplus peak will be 4.5% in 1999. Compared to the 10.1% surplus in 1991 the effect on the market and correspondingly on aircraft values should be less critical. But the amount of surplus aircraft depends strongly on the number of aircraft to be retired. The introduction of the stage II noise emission regulations combined with a lot of aircraft exceeding their 25th year of service life could help to significantly reduce surplus capacity. From the year 1998 to 2000, 348 aircraft per year are expected to be replaced (Plueger, 1998). Taking the cumulative difference between the seat growth and the traffic growth discussed earlier, the following graph can be received (Figure 25).

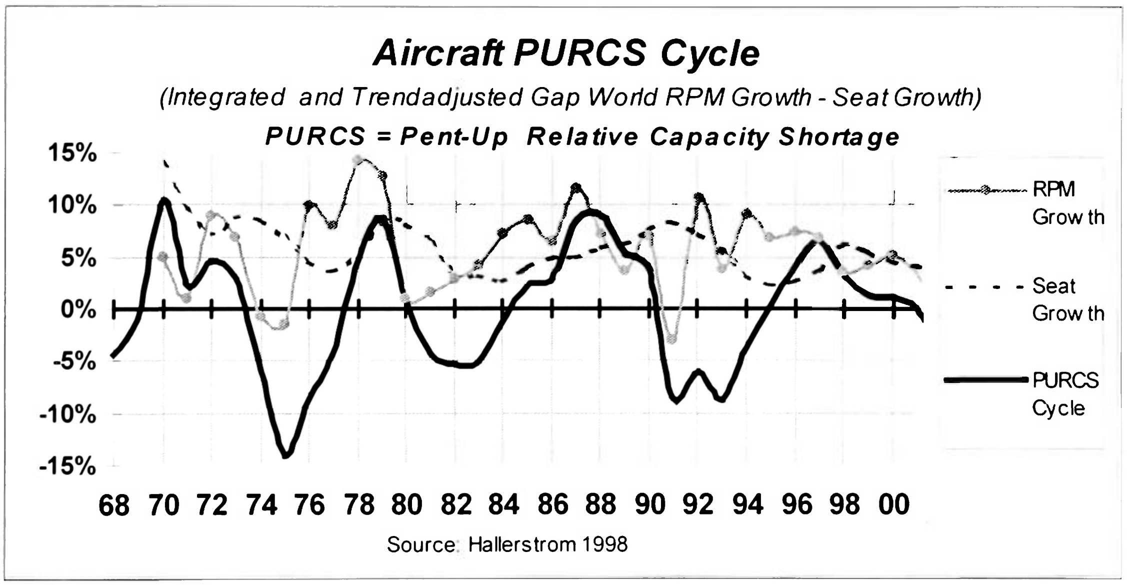


Figure 25. Capacity Shortage Determined by RPM Growth and Seat Growth.

The high correlation between the trend adjusted cumulative difference of RPM growth and seat growth with values of aircraft shows that the driving force behind aircraft values has been found. The amplitude of graph represents the pent-up relative capacity shortage (peaks) or surplus (through) called *PURCS* in the CL/PK *SAFE* model. Characteristics of the *PURCS* peaks are high utilization of the airline's equipment and high demand for seats i.e. aircraft to expand capacity. High demand and fixed supply results in values rising. While production rates are fixed in the short run, over-capacity results in decline of aircraft values. To adjust capacity especially older aircraft, which are to expensive to be operated at low load factors, become available in the market or retired. How strong an aircraft's value is pulled up or down by the *PURCS* swings is a function of the assets age and seat capacity. A young aircraft's operational efficiency combined with single aisle seat capacity lead to low cycle sensitivity and vice versa.

If all the industry knows the impacts of surplus capacity, why is nobody capable of preventing capacity to outgrow RPMs? The answer is: Market-share. The manufacturers could easily have their production rates swinging at more moderate levels and thereby preventing the cost and risk they are exposed to because of aggressively and still to slow changing their output. But the main competitors in the commercial aircraft market, Boeing and Airbus fear to loose market-share if they do not adopt their production rates to the short-term demand. Airbus is announcing that the main goal is to reach a 50% market-share. An example of 27% discount to a customer ordering only two A330s shows the dedication of the European consortium toward this goal (Aircraft Value News, 1998). Of course the manufacturers are considering the long-term relationship to a customer as more important than the short-term yields. However, there remains only the question if the cost for adopting output and the penalties for not meeting delivery deadlines will be compensated by expected future deals. The losses Boeing had in 1997 and 1998, due to a huge order backlog, show the danger involved in setting the goal too high for the production ramp.

3.2.4 Cycle volatility reduction

Can the volatility of demand for aircraft seats be reduced? Keeping demand artificial over the production rates the manufacturers could prevent the problems of continuous output adjustments. Such a solution is as unrealistic as a totally flexible manufacturing system that could be adjusted immediately to the market. The process to build such a sophisticated and customized product as a commercial aircraft is too extensive to react immediately to market changes. Much more standardization, a shorter supply chain and building a stock of standard modular components not very capital intensive, or using flexible just in time concepts for expensive parts are solutions to fight the cycle dilemma from a manufacturers perspective. Already, manufacturers try to move toward this goal. Two trends recognizable are that production rates were increased twice as fast as in the last cycle while lead times generally decline (Pluegler, 1998)

Another alternative to prevent the imbalance between supply and demand, would be a more future cycle sensitive ordering policy of the airline industry. But airlines also fear to loose market-share if they are not placing orders when the market indicates traffic growth. If the whole airline industry would have a better understanding of the cycles, the strong volatility could be reduced. Since core air travel demand can be predicted with a certainty of ±5%, an airline's fleet should have a 10% flexible component (Skinner, 1998). This would require innovative leasing and business ideas in order to be more responsive to demand. Airlines need to react anti-cyclical when planning their fleets. During the upturns aging and inappropriate equipment should be phased out, taking advantage of high yields. Short term leases and deferred retirements can be used to build up a marginal capacity. The marginal capacity should be reduced with the beginning of the down cycle. Then during the trough new equipment should be ordered at favorable conditions. Also heavy maintenance should be conducted while the utilization of the aircraft is low, thereby the aircraft has a low downtime when traffic is peaking again. If the airline is able to predict the cycle it will have big advantages over its competitors and also will reduce the cost of capital by proving the strategy to investors. If an airline is successfully this way, alliance partner or even competitors might follow the moves and thereby reduce the volatility of the cycles. Applying these hypothetical ideas in combination with the reduction in lead times, future cycles might become more moderate than today`s.

3.2.5 Technical status

Investors have one thing in common, they all want to get the highest return on their investments with the lowest exposure to risk. In contradiction to stocks and derivatives, technical products need to be evaluated on their overall technical condition in order to find their current and future values. Only then the expected return on the investment can be predicted with confidence. Since the most advanced technologies are applied to the very complex design of an aircraft, an extensive analysis is required to evaluate the technical status. The values of aircraft depend mainly on maintenance quality, the time to the next major check, utilization, and the technical configuration. Wear and tear of aircraft is not only evaluated on the basis of flight hours but also on the number of cycles. A cycle is one take off and landing or in other words one flight. Since the same type of aircraft can be operated on different stage length, i.e., routes with different distances, the average number of landings per hour can vary. A B737 for example operated in Germany solely on domestic routes will have average block times of about 60 minutes. The same aircraft type scheduled to the Mediterranean will have an average flight time of 3 hours per lag. As a result the aircraft used domestically would have 3 times as much starts and landings as the B737 used for the longer legs. While taking off and landing, the aircraft must withstand the highest stress. During the touch down and the deceleration the undercarriage is exposed to enormous forces. If the thrust reverse is activated after the touch down the engines and the wing are also stressed heavily. Even if both aircraft would be otherwise exactly the same, the lower hour to cycle ratio of the aircraft flying only short lags would reduce the value.

Maintenance intervals are based on these two measurement units. Each airline may have its own maintenance program approved by the country's aviation authority. But the manufacturers recommend to use their maintenance-planning document (MPD). Typically aircraft checks are called daily, weekly, A, C, or D-check. The Boeing MPD for the B737-300 for example assumes an average flight length of 1.4 hours and 8 hours utilization per day. Based on these assumptions A-checks and C-checks are due every 200 and 3200 hours respectively. If an operator's average flight length deviates from the previous assumptions, the C-checks must be performed between every 3000 to 4600 flight hours or 2000 to 2611 flight cycles. If a customer would not accumulate the amount of hours the aircraft must undergo the C-Check every 12 to 24 months. The 7th C-check is the equivalent to a D-check. To understand the importance of the remaining life to the D-check Figure 26 presents the cost distribution of 7 B737 C-checks. The closer an aircraft comes to a D-check (7C), the lower its value.

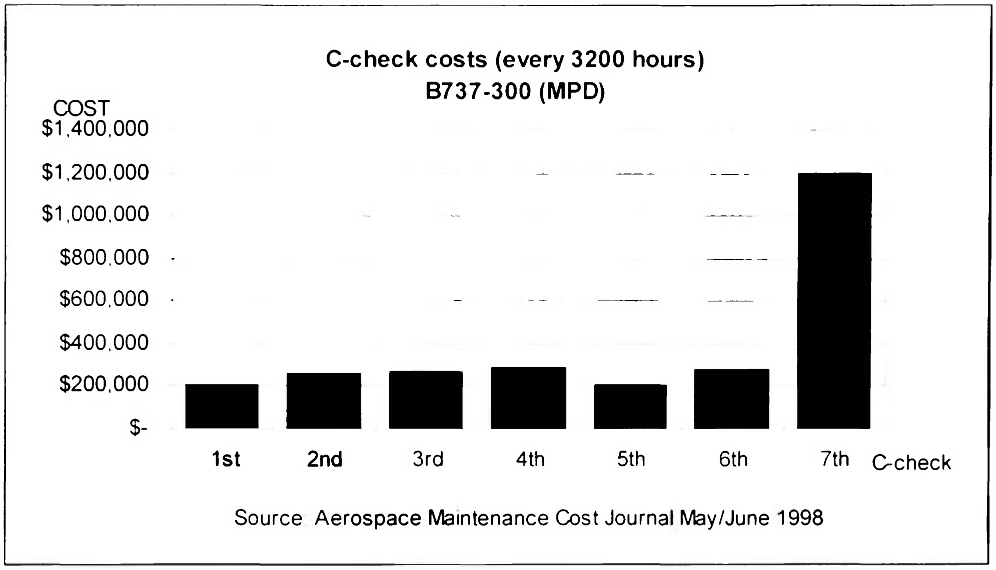


Figure 26. C-Check Cycle.

Maintenance cost of an engine show significant differences depending on the average cycle length. A V2500-A1 engine operated at 1 hour cycles requires $120 to $142 of maintenance cost per flight hour, while the same engine used on 3 hour cycles can be maintained for $68 to $81 per flight hour (Clark, 1998). An increase of 75% engine maintenance cost for a 3 to 1 hour average cycle length reduction also illustrates the importance of the hour to cycle ratio for the aircraft evaluation.

Values of Aircraft configured with special technical equipment decline slower than those of standard versions. As can be seen in Figure 27, a B757 build in 1988 is as a basic version in 1997 30.4% less worth than the same type with better engines, increased gross weight and extended range. The value of the "high spec" derivative kept about 72 % of its 1988 price while the value of the standard version declined to about 59%.

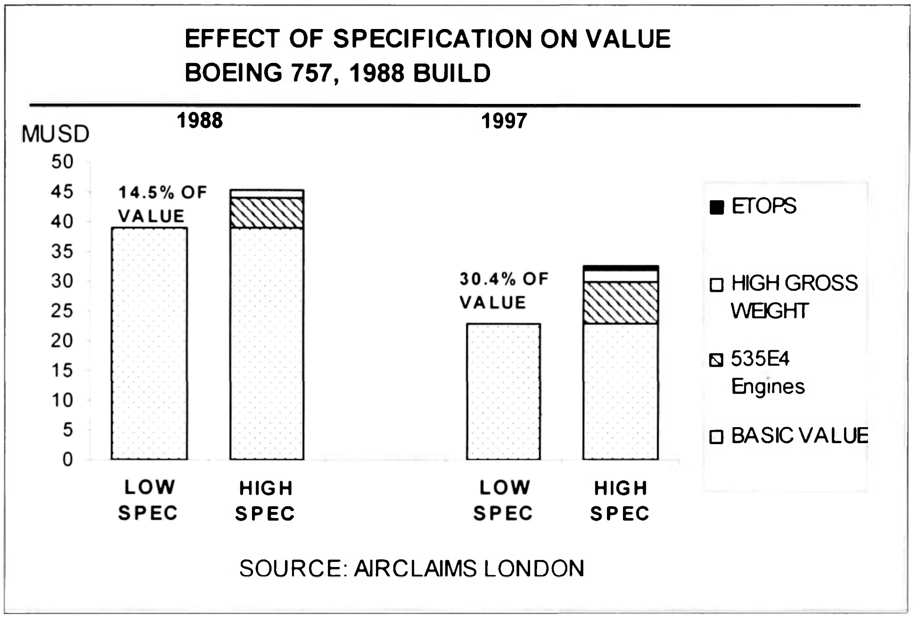


Figure 27. Impact of Technical Configuration on Aircraft Values.

The examples listed above show how aircraft specific technical characteristics can have major implications for individual aircraft evaluations. The multitude of possible configurations and utilization combinations explains why it is hard to determine one single current market value for an aircraft type, when each individual aircraft is almost unique.

The strict rules for documentation should make it relatively easy to evaluate the general maintenance status of an aircraft. However, the process of moving an aircraft to another operators maintenance program can create expensive bridging checks if the documentation of the previous owner is not transparent or standardized. One item of bridging checks is the very expensive and in most transactions required boroscope analyses, which is the only technique to evaluate engines accurately. As mentioned before maintenance programs of different airlines may vary significantly. While some operators prefer the block maintenance plan, having accumulated major events, others divide the big checks and add the work to more frequent minor checks, called phased maintenance. The argument for phased checks is that the smaller work packages do not require the planning of extreme long downtimes in an aircraft utilization schedule. Components need to be made accessible only once and no work needs to be done two fold is said to be an advantage of block maintenance. Switching the aircraft from block to phase or vice versa can result in costly redundancy of work.

Appraisers evaluate the aircraft's maintenance condition very often by comparing the performed maintenance with the MPD. Variations from the MPD resulting in more extensive bridging checks result in a lower value of the aircraft (Seymour, 1998). Since the aircraft is an asset and will most probably be sold after a certain time, the operator should view maintenance expenses as an investment rather than a cost. A part of the cost for high quality maintenance will be recovered from the higher sale proceeds while the airline simultaneously can uphold a high reliability of its fleet. A reliable aircraft also ensures on time performance, less delay cost and finally a higher customer satisfaction.

High quality maintenance does not require any extravagant expenses or continuos upgrading of the aircraft. Modifications are justified if they improve the aircraft's efficiency in order to strengthen its future value. Reasonable upgradings are the installation of hushkitts or re-engining if the economical life becomes extended sufficiently to create a return on the investment. Additional critical factors for the marketability are aircraft's compliance with service bulletins (SBs) and Airworthiness Directives (ADs). While service bulletins issued by the manufacturer are only optional or recommended, airworthiness directives declared from the aviation authority are mandatory in order to maintain the aircraft's airworthiness certification.

3.2.6 Inflation

In general inflation is an increase in the average price level. The data used to measure inflation are the Consumer Price Index (CPI), the Producer Price Index, or the GDP deflator. The following figure shows the historical CPI development in the United States (Figure 28). The US index is the standard used in the aviation industry, since aircraft are traded in US Dollars.

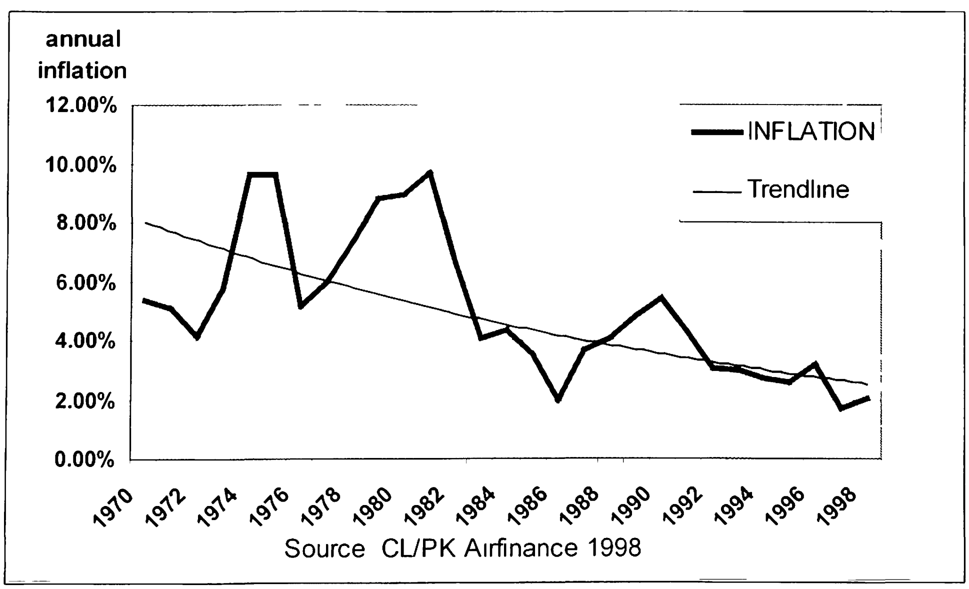


Figure 28. Historical U.S. Inflation with Trendline.

Fitting a trend-line to the graph a general decrease can be recognized. According to the historical volatility and the current development of full employment with wages rising in the US there exists a chance for increasing inflation. It is not the purpose of this paper to address the different economical theories but to discuss the influence of inflation and its predictions on aircraft values. By taking the projected forecast of one appraiser at constant Dollars and discounting these values at different inflation rates significant variation of the values in current US Dollars can be found (Figure 29). By looking at the big difference between the values one can imagine what long-term implications a wrongly assumed inflation rate might have on forecasted values.

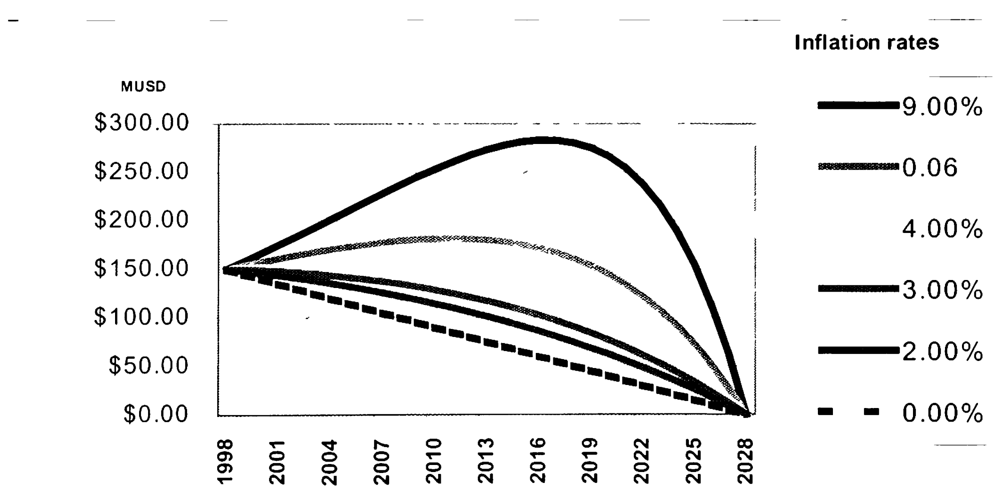


Figure 29. Impact of Inflation Rates on Straight Line Depreciated Aircraft Values.

Over a forecasting horizon of 15 years a wrong assumption of the inflation rate by 1% may result in 1 to 2 million deviation of the aircraft value. Even more extreme can be the impact for newer wide-bodies worth 100 to 160 million Dollar. Considering these amounts of money a variation of one percent inflation may easily result in a 10 to 15 million deviation of the aircraft's future value. The prediction of future inflation is therefore an important part of the future value calculations. As inflation is important to all aspects of an economy, appraisers can take advantage of data published sources such as government agencies specialized in this topic.

3.2.7 Switching costs

All airlines offer in general the same product, a flight from A to B. Besides the age, carrier are using more or less the same aircraft, flying at the same speed, and making the same noise. To differentiate the product, airlines require highly customized cabin configurations to establish a recognizable and lasting corporate identity. The passenger does not associate the factors such as price, service, route network, or non stop connections with the aircraft itself. The operators are willing to pay a high price because new aircraft are unique products designed according to the airline wishes. The high degree of customization may become a disadvantage when the aircraft will be sold. Besides technical variations, which do not need to be changed necessarily, the cabin configuration and design often needs to be adjusted to the new operator's corporate identity. Especially operating lessors are facing this problem frequently. But the different aircraft types combined with the variation in configuration make it hard to determine a specific price for the refurbishment of one aircraft type. While some airlines might want new cabin equipment others just want to have the language of signs changed or parts carrying the airlines logo adjusted. Sometimes technical changes are mandatory due to requirements of a country's aviation authority. In the USA for example, the FAA requires TCAS (Traffic Collision Avoiding Systems) and wind-shear warning systems. According to an Airbus employee, even a minor adjustment costs generally around $100,000. Changing an aircraft from a two or three class into a single class seat configuration for charter operations costs around $0,5 million to $1 million.

Very expensive becomes a reconfiguration if toilets and galleys need to be exchanged or repositioned. Therefore most airlines have these components just adjusted to their design. Galley refurbishment for a B737-200 costs around $60,000 while the new equipment would be three times as expensive and cost up to $175,000.

According to FLS-Aerospace, "a standard 747 refurbishment consumes about 5000 to 6000 man hours". At a rate of $45 per man hour this accumulates to $225,000 to $270,000 without any materials. The minimum work includes recovering and retrimming of the entire decor and bringing the interior to a serviceable condition with the minimum effort. Since most B747 operators have a similar cabin configuration, transactions involve in most cases only minor interior refurbishment as described before. But for major exchanges like the installation of new seats, passenger service units (PSUs), toilets and galleys for a B747, Pemco World Air Services estimates a downtime of 45 days. The installation would require about 3250 man hours or around $150,000. The material cost would amount to around $2 to $3 million. According to Airclaims a Cabin refurbishment of a 1972 B747-200 can accumulate to about $10 million. In a B737, the equipment could be installed within 20 days downtime and 1100 man hours. Another example where a B737-200 lay out was changed from a 109 seat to a 130-seat configuration, with new galleys and the rest of the cabin refurbished the labor accumulated to 5000 hours

(Juggling the hot coals of aircraft cabin refurbishment, 1997). These examples indicate that the cost for cabin refurbishment may vary for each individual case significantly. On top of the interior modification the transformation of an aircraft from the old maintenance plan to the new operator's maintenance plan, may impose a further big cost factor, known as bridging cost. Especially the switch from a block maintenance plan (complete D-checks) to a phase maintenance plan (divided D-checks) can become extremely expensive. Depending on the amount a customer has to invest in the adaptation of an aircraft to its fleet he is willing to pay more or less for a used aircraft.

3.2.8 Operating Cost development

Depending on the airline's organization the cost structure varies considerably. Many variables as fuel price are not constant and are difficult to anticipate. Even though the fuel consumption is decreasing with technological advancement the price of fuel is volatile. Crew cost depends on the wage level and the power of the unions.
A further share of the operating cost is covered by the maintenance of the aircraft. Ranging from 5% to 15%, maintenance costs also depend on many variables and are not consistent within the industry (Non-routine maintenance and the economic equation, 1996). In low-income countries the composition of the maintenance cost is totally different to high-income countries like Germany. The cost for spare parts and components may differ significantly due to the exchange rate of a country's currency. Like aircraft, parts and components are traded in US dollars. Furthermore, the aviation authorities in different countries may require special maintenance programs.

Since it is impossible to take just an average or one example of the operating cost composition and analyze nominal values, it has more value to concentrate on the trends in the industry. Analyzing trends should enable one to extrapolate the future development of operating cost. Nobody can exactly predict how much an overhaul of a specific aircraft will cost in the future but looking at the historical cost development we should find trends for new and old technology. Further reasons for varying maintenance costs result from the fact that in low-income countries the pressure to increase productivity and optimize procedures is lower as in high-income countries. Due to the competition from low income countries and the cost pressure in the airline industry declining maintenance costs can be expected for the future. Another factor is the size of maintenance facilities resulting in different economies of scale. Furthermore, it needs to be analyzed how much maintenance cost become reduced by technological advancement of new aircraft.

As a general result, we can say that according to the cost pressure on maintenance facilities and the technological development the maintenance cost are continuing to fall. It can be expected that this cost decline will slow down as long as there are not any major technology leaps.

The maintenance for new aircraft finishing their prime life is expected to rise slower than old models did. For the base value the final implication would be that modern aircraft's economical life will be extended and due to the increased cash flow generating potential the values depreciate slower. That conclusion assumes all other variables constant and market equilibrium.

3.3 Forecasting uncertainty

For large investments such as aircraft, the potential for an upside and the amount of risk a deal bears are very important factors for the investors. The parties involved like to measure the risk they are exposed to when financing or investing in aircraft. The standard deviation of the expected return used to measure risk. Aircraft future values are assumed to be normally distributed (Figure 30). With a standard deviation of ±1, the confidence level for predicting a future value is increased to 68%.

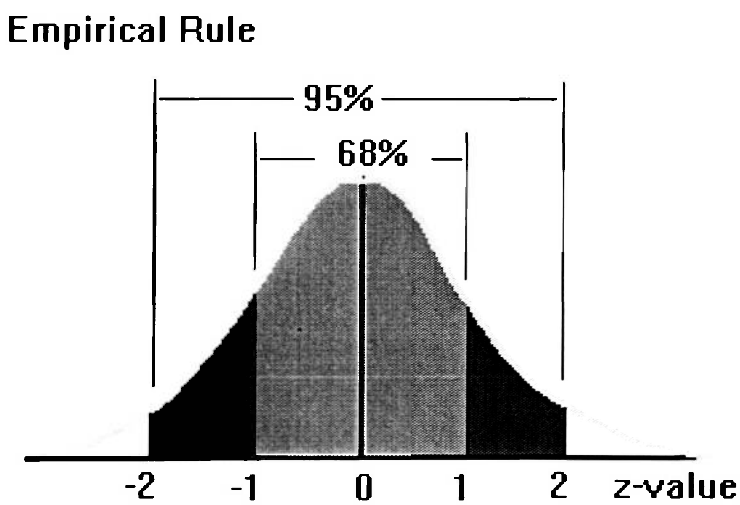


Figure 30. Normal Distribution.

Being able to measure the risk by knowing the probability for a worst case scenario, investors can be attracted easier. Investors become more and more important since they provide the vast amount of capital needed to expand and replace airline fleets. Another possibility to measure the risk potential of an aircraft investment, is the analysis of forecast accuracy. By looking at historical data, an appraiser's forecast accuracy and its standard deviation can be determined. Knowing the standard deviation of an appraiser's aircraft value forecast accuracy would make an appraisal much more valuable for an investor.

Credit Lyonnais/PK Airfinance's SAFE model shows the standard deviation over the forecasting horizon. The initial standard deviation at the time t = 0 is derived from historical experience. Like other models for pricing options and derivatives the Brownian motion of stock prices theory is applied to the forecast of aircraft values (Hallerstrom, 1998). This theory assumes that the standard deviation grows by a square root function of time.

$$\sigma(t) = \sqrt{\sigma_0^2 + \frac{t}{t_1}(\sigma_1^2 - \sigma_0^2)} \qquad (15)$$

Where σ_0 is the initial standard deviation at $t = 0$ and σ_1 is the standard deviation at $t = t_1$ (CL/PK Airfinance, 1998).

The growing standard deviation reflects the increase of the uncertainty the aircraft value prediction bears. Especially the anticipated timing of cycles becomes less accurate the longer a forecast horizon. With the hard to predict demand-cycle determining the aircraft value, the value forecast becomes less accurate the longer the forecast horizon becomes (Figure 31).

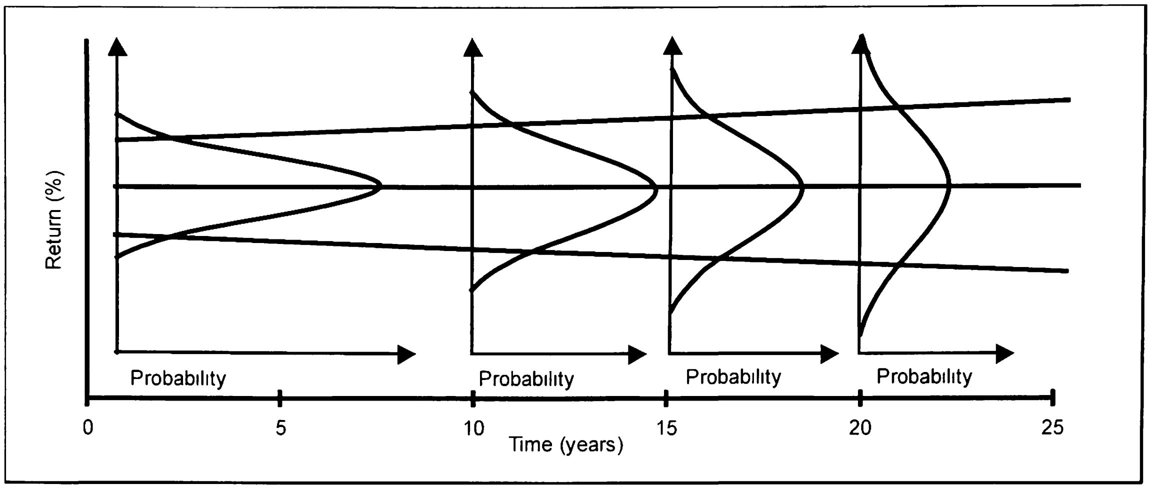


Figure 31. Decreasing Confidence Level for Longer Forecasting Horizons.

Most aircraft value projections neglect information about the confidence level. Since many financial institutes are not capable of predicting aircraft values or evaluating appraisals, they depend heavily on the appraiser's judgment. The forecast accuracy and disunity in the appraisal industry will be discussed later in separate chapters.

3.4 Forecasting models

3.4.1 The Aircraft Value Analysis Company

The forecasting model used by The Aircraft Value Analysis Company (AVAC) produces future and current market values. Various assumptions regarding world economy, air transport industry, and supply demand cycles are necessary to determine the aircraft values. The values reflect transactions of single aircraft from willing sellers to willing buyers, paid in cash.

Current Market Value:

To a certain degree historical transaction data and list prices of new aircraft are included in the calculation of the aircraft values. But this data needs to be viewed critically, since list prices may include services and do not reflect the actual discounted prices airlines pay for the aircraft. Transaction data if available are not transparent enough to understand the specific details of a deal. Further factors for the evaluation of the aircraft are market penetration, position in the product life cycle, and the technological status.

Future Values:

After determining the economic service life of an aircraft, the future values are calculated by adjusting a reference value for anticipated world economic and aviation industry specific developments, with a maximum projection period of 15 years. The AVAC applies a Phase Analysis to project future values of aircraft. The model divides an aircraft's life into 5 to 7 periods, which can be stable, falling, or rising. During the first phase, the introduction of the aircraft, the aircraft value is rising during a boom and falling in a recession. In times of balanced seat and traffic growth the phases are considered to be stable. During its economical life an aircraft passes through 5 to 7 of these phases. To forecast the state of the economy, AVAC uses GDP, inflation, interest rates and oil prices published by Great Britain's clearing banks. The four variables are main indicators to determine airlines' degrees of expansion. It is assumed that rising fuel prices and low interest rates make airlines acquiring rather new than used equipment. Especially the GDP growth is seen as an indicator for air traffic growth and airline's fleet expansion. For forecasts over eight years the model is giving a lower weight to the economic variables since the uncertainty rises with longer forecasting horizons.

The forecasted GDP growth in combination with predicted yields and the degree of improvement is the foundation of the traffic growth calculations. In addition to the calculation of up and down swings, a constant is used to accommodate for the general trend of increasing traffic. Using the economical indicators and environmental regulations to find the number of future retirements, the demand for additional units is calculated. Comparing the demand for additional units and the output of new aircraft (backlog and production rates), the imbalance between supply and demand is found.

Applying the economical variables and the aviation specific data, the base line of an aircraft's value depreciation is adjusted for the cyclical development of air traffic growth. Subsequently the values are adjusted according to an aircraft specific scoring system. The following factors are given different weight. The result is a figure used to adjust the initial base value upwards or downwards, representing the aircraft's potential for re-marketing:

Table 7

Factors Determining Aircraft Values

➢ Average annual production	➢ Number in service
➢ Availability	➢ Years since introduction
➢ Number of operators	➢ Specific age
➢ Geographical distribution	➢ Maintenance Status
➢ New or derivative	➢ Configuration
➢ Commonality	➢ Engine type
➢ EFIS	➢ ETOPs
➢ Number of engines	➢ MTOW
➢ Proportion of lessors	

The final aircraft value curve is adjusted for the correlation between values and air traffic growth and aircraft specific re-marketing potential. The AVAC provides a best case and worst case scenario to accommodate for unpredictable future scenarios.

3.4.2 Avmark

The Avmark aircraft value forecasting model is based on the theory that the theoretical value of an aircraft depends on its revenue generating capacity. Avmark distinguishes between price and value of an aircraft. The price is a function of the value and the willingness of a buyer to pay for the profit generating potential. The willingness to pay depends on many factors, but mainly on the stage in the industry cycle. Besides the cycle, the investors' confidence in the asset, cost of capital, demand for an aircraft type, availability of aircraft type, and marketability of the asset are considered important factors influencing the price. According to the imbalance of seat capacity the price continuously fluctuates around the theoretical value. A profit and loss analysis is conducted to build a calculation base assessing all future cost and revenues accruing to an aircraft type over its economic life. The data are translated into a profitability curve showing the base depreciation and the anticipated end of the aircraft's operating life. The basic assumptions consistent for every aircraft type are the as follows:

- aircraft is in an overall good condition,
- aircraft is deemed airworthy (AD, SB),
- aircraft is maintained according to a maintenance program approved by a national regulatory authority,
- aircraft has a standard configuration,
- aircraft has been utilized on industry average,
- aircraft is free of liens.

The next step is to apply the aircraft's individual data to the model. For the seating capacity the industry average is assumed. The long-term load factors necessary to calculate the future revenues are derived from industry capacity forecasts. Regression analysis is used to project revenue yields for the different length of haul. Airspeed is also projected by regression analysis since distance and speed are supposed to be highly correlated. Utilization is estimated because the number of cycles per day is determined by stage length while for the ground time average values can be used. The data for operating expenses, obtained from industry sources is also averaged. The lower maintenance cost for young aircraft and the increasing fuel consumption of old aircraft are taken into account. The fuel price is assumed to be constant over time.

To find the net revenue generating potential of an aircraft passenger processing, general and administrative costs are also included in the model. Depreciation and interest cost are neglected since they are not closely related to the aircraft operation itself. The aircraft specific data and actual transaction data are applied to an initially developed aircraft profitability curve. In order to receive the final future values of the aircraft, current values are calculated by subsequently incorporating expected future inflation rates. Governmental and industry inflation predictions are applied to the different cost and revenue positions, averaged, and than translated into one future inflation rate. This rate is used to calculate the final future values in current dollars. Avmark is biannually publishing its final results in a statistical report called Transport Aircraft Values (TAV).

Looking at the final plots of Avmark's forecasts, the depreciation patterns can be recognized (Figure 32). Despite the knowledge and the pretended application of up and down cycles in the forecasting model, Avmark's predictions do not show any cyclicality.

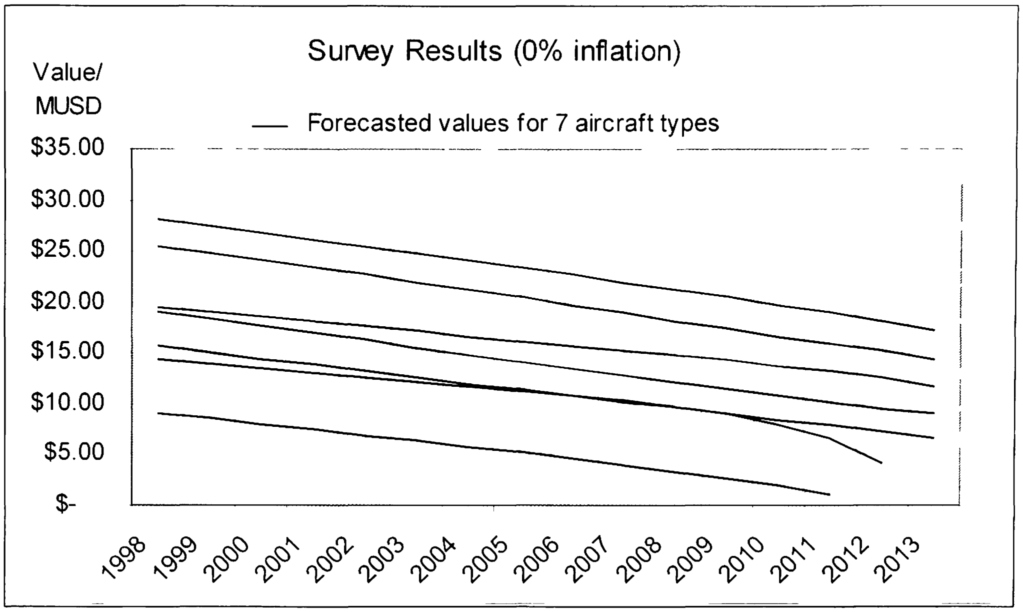


Figure 32. Avmark Aircraft Value Forecasts for Seven Different Aircraft Types.

3.4.3 SAFE

The prediction of future aircraft values is only one feature of the model developed by Credit Lyonnais /PK Airfinance, called SAFE (Statistical Aircraft Financing Evaluation). The model calculates future values to evaluate aircraft backed loans and investments. By changing the input variables the user is able to find the best constellation for his deal. There are four types of input necessary: Information about the aircraft, the cycle, the obligor, and the loan.

To forecast future value for an individual aircraft, date of manufacture, type and current market value are required. To determine the position in the cycle, the date of the last recession, the anticipated date of the next recession and the date and amplitude of the boom in between need to be inputted. A detailed result sheet shows both figures and graphics explaining the yield potential, the asset's future value uncertainty and the obligors default risk. Since the paper is discussing the prediction of aircraft future values, the author neglects the deal evaluation capabilities of SAFE.

The model's aircraft future value calculation is based on 3 factors. First, the typical depreciation curve, discussed in chapter 3.2.1, determines the reference value. The reference value (RV) represents the revenue generating capacity and correspondingly the anticipated economical life of the asset. Concerning the age, the end of the prime life is important since the value is not degrading linear anymore but exponential from that point in time. As described in chapter 3, CL/PK has developed a mathematical formula to calculate the RV. CL/PK Airfinance used its' data base of historical transaction data to find the depreciation patterns and the RV formula. The reference value, which represents the net present value of the aircraft's cash flow generating capacity in constant Dollars, is subsequently adjusted for future inflation. The derived "inflation adjusted" reference value (IARV) is the base value, which is adjusted for the market development. Since the price of an aircraft is very elastic and driven by the ratio of demand and supply, the disharmony of orders and deliveries is resulting in a cyclical pattern of the prices over time. Values of some aircraft show a higher degree of correlation to the cycle than others. To compensate for that, SAFE uses a cycle sensitivity factor for each aircraft type. Two factors are mainly responsible for the aircraft's cycle sensitivity. Depending on operating economics and size, aircraft values stay relatively stable or swing heavily up and down over the economic life. Smaller aircraft with modern technology allowing more efficient operations because they can still generate positive cash flows when load factors are going down. The high share of variable cost of older equipment requires high load factors to keep their operation profitable. In times of recessions it is obviously harder to fill up a wide-bodied aircraft than a narrow-body. Since the number of aircraft with more than 230 seats represents only 26.9% of all aircraft grater than 50 seats, the chance for marketing these aircraft compared to narrow-bodies becomes smaller in times of over capacity (Boeing, 1998). This results in the values of wide-bodies falling faster than values of narrow-bodies, which are easier to be relocated. Conversely, as air traffic grows faster as seat capacity, even older wide-bodied aircraft can be flown efficiently. The relative shortage of wide-bodies compared to the narrow-bodies can result in a stronger upswing of their prices. Modern technology and low capacity make an aircraft value least volatile to the cycle. Depending on these factors, cycle sensitivity factors are applied to the aircraft type. Due to the uncertainty rising with the time horizon of the prediction, an exponential dampener reduces the cycle adjustment over time.

Furthermore, SAFE does allocate Type Penalties to the different aircraft types in order to adjust for factors resulting in low market penetration. Aircraft, which have special characteristics, valuable only to a few operators, result in a value lower than the theoretical reference value.

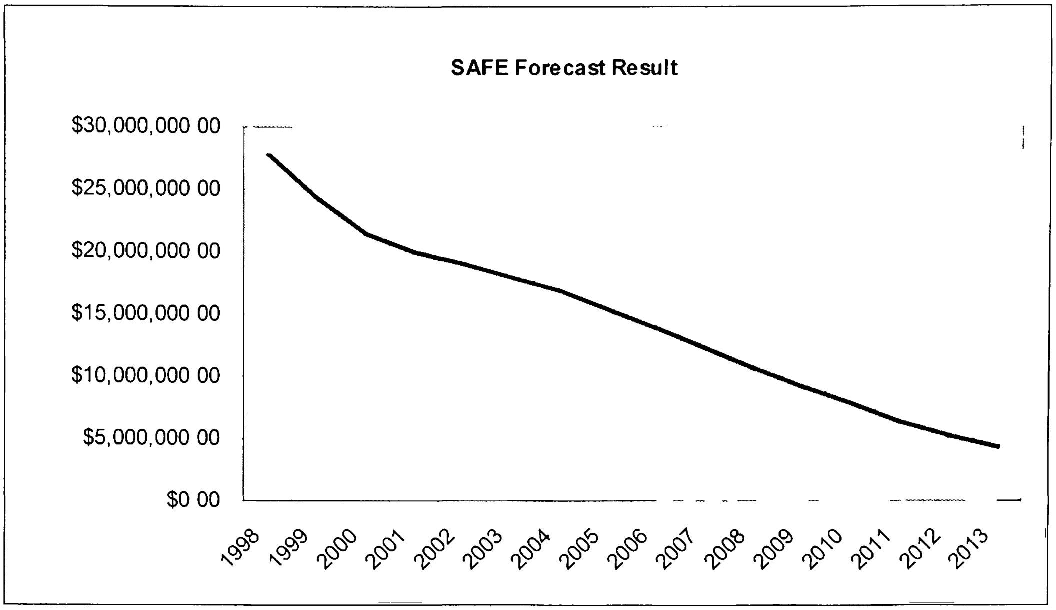


Figure 33. Example of SAFE Aircraft Value Forecast.

Figure 33 exhibits the incorporation of cyclicality in a SAFE aircraft value forecast. The following formula incorporates the factors described before.

$$\nu(\exp) = IARV \times (1-\delta) \times (1+\beta \times C) \qquad (16)$$

β = cycle sensitivity

$\nu(\exp)$ = current fair market value

IARV = inflation adjusted reference value

δ = type penalty

C = aircraft value cycle relative amplitude

The inflation adjusted reference value, IARV is adjusted by the type penalty, δ. The higher the type penalty, the lower the value of the aircraft relative to the IARV. "A type penalty is applied for aircraft types that lack market penetration (few units delivered and few operators, hence poor liquidity), where the manufacturer has exited the business (e.g. L1011)" (CL/PK Airfinance 1998). The cycle sensitivity β represents to what degree the aircraft value corresponds to the cycle. "Preliminary research shows that number of seats and operating economics are two important factors. Aircraft with high seat capacity and poor operating economics display large swings in value. Smaller aircraft of modern technology will show more modest swings, around 10-15%, based on our research." (CL/PK Airfinance 1998).

The cycle is determined by the aircraft value cycle relative amplitude, C. SAFE uses segmented sinus curves to replicate the cycle" (CL/PK Airfinance 1998). In order to account for the growing uncertainty regarding the timing of the cycles in the future, C is reduced exponentially over time. As a result, values forecasted for the far future show less volatile amplitudes (Hallerstrom, 1998).

4 Analysis

4.1 Historical forecast accuracy

So far it was explained why it is important to forecast commercial aircraft values, how the values depreciate and which factors the industry assumes to drive aircraft values up or down. But especially for investors paying a lot of money for appraisals, in order to evaluate their risk exposure, it is important to know the accuracy of these predictions. In order to evaluate the risk of a specific deal, investors like to know the average error and the standard deviation of historic forecasts. If thoroughly analyzed, the historic accuracy is a good indicator of expected future forecast accuracy. For the methodology chosen it is necessary to have available the historic data of a series of consecutive forecasts. At CL/PK, the information in the right format was available for Avitas. In order to evaluate the SAFE forecast accuracy, historic forecasts needed to be simulated on the basis of assumptions made at the starting point of the forecasts in the year 1989. Since CL/PK is not a provider of appraisals, aircraft value predictions are only applied to each aircraft underlying a specific deal. It is possible to simulate historic forecasts by feeding inflation, cycle and aircraft specific data into the SAFE model (Statistical Aircraft Financing Evaluation). The forecast accuracy was conducted for the same 7 aircraft types (Table 1, Page 13) used in the survey analyzed in the following chapter

4.1.1 SAFE Forecast Accuracy

Now that the methodology has been explained, the model will be applied to real forecasts. In the beginning CL/PK's SAFE model will be analyzed in regard to its forecast accuracy. Unfortunately there are not sufficient historic forecast data available. The reasons are that on the one hand CL/PK's SAFE software was not developed before the early nineties and on the other hand SAFE is applied to each deal specifically. Deal evaluation and aircraft value forecast are combined in one process. There is no database available including all historic forecasts, because the software is designed to produce always the most current forecasts applied to each deal at CL/PK.

However, in SAFE it is possible to simulate forecasts starting any time in the past. The one and only downside of the simulation is that the results could be more accurate than an actual projection would have been because dates of downturns and booms, two of the SAFE inputs and major factors influencing the aircraft value, can be determined exactly for the past. The argument that justifies the use of these simulated forecasts is that the cycle were forecasted, based on the ratio of traffic growth and seat growth, where as the later is determined by relative inflexible and foreseeable aircraft production rates. The input assumptions are as close as possible to the expectations prevailing in the industry in1989. The forecasted values, actual values and the average errors with their corresponding standard deviations are available in graph format. Here, the final results of the SAFE forecast accuracy are discussed. It is important to bear in mind that the SAFE forecasts are compared with the current market values of Avitas. As discussed earlier, Avitas CMVs were assumed to be the correct trading values from 1989 to 1998 because there are no consistant historic CMVs availble. The advantage of using Aviats' CMVs is that different forecasts can be evaluated on the same basis.

The following two tables exhibit the mean of the error and the standard deviation of the error for each aircraft type and forecast horizon. Table 8 contains the mean of errors for each aircraft type and each forecast horizon. How the values were calculated is explained in Chapter 1.5. The analysis of the SAFE forecasts led to multiple negative error values. Negative errors indicate that the forecasted values for this specific forecast horizon were on average to low. Consequently, positive values represent an average upward deviation from the actual values. In order to get an overall understanding of the SAFE forecast accuracy the results of the individual aircraft analysis are summarized in two categories: Narrow-bodies and wide-bodies. By having only two categories, it is easier to compare the results of different forecasting models. The plots for each individual aircraft can be found in Appendix A. For the B747 the mean of the error was -41% for a six month forecast horizon (Table 8). From Table 9 it can be learned that these mean error was not consistent since one standard deviation amounted to 35%.

Table 8

Systematic Error of SAFE Historic Predictions for Different Forecasting Horizons

Horizon	Mean of Error for different forecast horizon by aircraft type						
Month	B747	A300	DC10	A320	MD83	B737	B757
0	0%	0%	0%	0%	0%	0%	0%
6	-41%	-45%	-29%	-4%	-16%	-2%	-14%
12	-43%	-45%	-27%	-3%	-15%	-3%	-14%
18	-46%	-43%	-23%	-1%	-15%	-2%	-13%
24	-47%	-39%	-18%	1%	-14%	-2%	-12%
30	-48%	-30%	-9%	2%	-12%	0%	-11%
36	-44%	-23%	0%	3%	-10%	2%	-9%
42	-39%	-16%	8%	2%	-9%	1%	-8%
48	-34%	-8%	15%	2%	-8%	1%	-8%
54	-29%	-3%	20%	2%	-7%	1%	-7%
60	-28%	-2%	21%	1%	-9%	0%	-8%
66	-28%	-1%	21%	0%	-10%	-2%	-8%
72	-37%	0%	20%	-1%	-13%	-4%	-7%
78	-47%	-3%	17%	1%	-15%	-6%	-8%
84	-59%	-5%	14%	4%	-18%	-8%	-9%
90	-77%	-7%	10%	5%	-19%	-10%	-10%
96	-86%	-14%	6%	2%	-22%	-14%	-11%
102	-96%	-23%	3%	3%	-25%	-17%	-11%
108	-110%	-36%	-2%	0%	-28%	-21%	-12%
114	-132%	-41%	-4%	0%	-30%	-22%	-11%
	Wide-body			Narrow-body			

In Table 9, the average value of one standard deviation of the error for each aircraft type and forecast horizon is listed. The standard deviation is the root mean square of the deviations from the mean. For normally distributed samples, 68.27% of the cases are included between one standard deviation on either side of the mean (Spiegel, 1991). The standard deviation is helpful to understand the range of the data since the mean of two retrograde errors might be 0. In Table 8 as well as in Table 9 the values for the B747, A300 and DC10 (wide-bodies) are much higher than for the B737, B757, MD

83 and A320 (narrow-bodies). Thus, a categorization of the data into wide- and narrow body is justified.

Table 9

Values for One Standard Deviation of SAFE Historic Predictions for Different Forecasting Horizons

Horizon Month	One Standard deviation						
	B747	A300	DC10	A320	MD83	B737	B757
0	0%	0%	0%	0%	0%	0%	0%
6	35%	51%	41%	7%	17%	7%	10%
12	36%	51%	43%	7%	17%	8%	11%
18	39%	53%	45%	7%	17%	10%	11%
24	44%	54%	46%	6%	17%	11%	11%
30	50%	51%	42%	6%	16%	10%	9%
36	49%	46%	36%	7%	12%	8%	6%
42	46%	40%	29%	8%	12%	7%	6%
48	43%	31%	20%	8%	10%	5%	5%
54	36%	20%	10%	7%	5%	4%	4%
60	34%	18%	8%	6%	4%	5%	5%
66	31%	16%	7%	3%	3%	5%	5%
72	30%	14%	8%	6%	3%	5%	5%
78	26%	15%	8%	6%	4%	4%	4%
84	18%	17%	8%	4%	3%	3%	4%
90	10%	19%	6%	3%	2%	3%	5%
96	13%	20%	6%	0%	3%	1%	3%
102	20%	19%	6%	0%	2%	4%	3%
108	19%	8%	5%	0%	4%	7%	0%
114	0%	0%	0%	0%	0%	0%	0%
	Wide-body			Narrow-body			

As was explained in Methodology, the statistical validity for longer forecast horizons decreases due to a reduction of data available. Therefore, the further discussion includes only the results of forecast horizons of up to 6 years or 72 month. Figure 34 shows the average forecast error sorted by aircraft category. The values forecasted for narrow-body jets show the lowest average error. The mean deviation of the SAFE forecast from the Avitas CMVs for narrow-body jets is fairly consistent. While for a 12 month forecast horizon the error lies at about negative 9%, it is reduced to negative 4% for the 6 year forecast horizon. The trend of improved accuracy is also found for the wide-body aircraft. Averaging about negative 40% deviation for 12 month the error is reduced to about negative 30% for the 6 year forecast horizon. The tendency of negative errors, which indicate too low forecast results may be explained by the business characteristic of CL/PK. As a finance institute, it is reasonable to make conservative forecasts in order to reduce risk exposure.

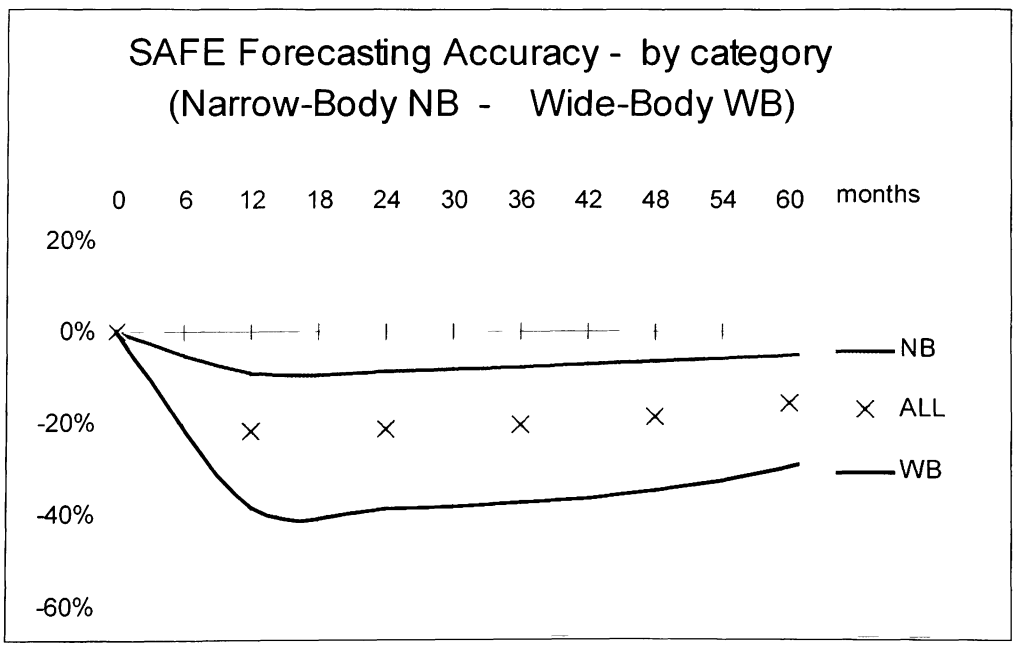


Figure 34. SAFE Forecasting Accuracy.

While especially for the narrow-body jets the average forecast accurcy of SAFE is very high, the standard deviation needs to be examined, too. Only by analyzing the mean of the error together with the standard deviation, an absolute evaluation of a forecast can be accomplished. Figure 35 shows the mean of the error and the corresponding standard deviation for the narrow-body and wide body category. For both aircraft categories the standard deviations are consistent for different time horizons. While for the narrow-body forecasts the standard deviation lies in the 8% to 11% range, the error for the wide-bodies shows higher variations. Up to 48% is the standard deviation in this category.

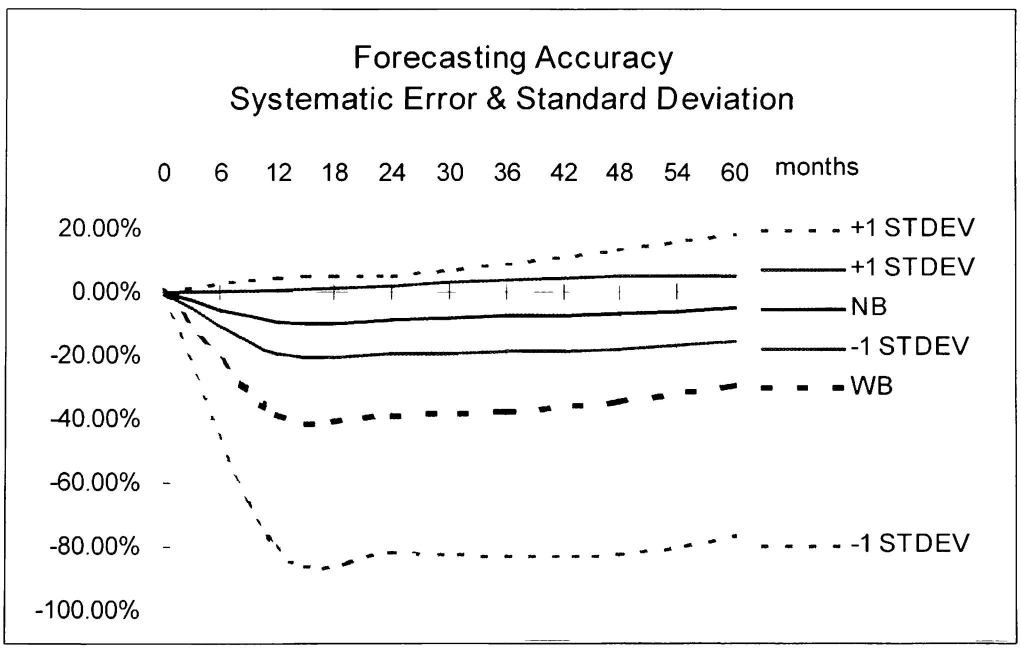


Figure 35. SAFE Systematic Error with +/- One Standard Devation.

Resulting in a low systematic error while simultaneously the standard deviation remains close to 10% the SAFE forecast accuracy for narrow-body jets can be considered very god. The wide-body values show a hιgh standard deviation and a systematic error of close to 50% lower than the CMVs. One reason for the high deviations can be seen in Figure 36. The CMV, which are the startıng points for each forecast, are very high in the early years of the forecast horizon. The sıgnificant drop of the first forecasted values ındicates, that the Avitas CMVs are inflated in comparison to the values SAFE is based on. One of the reasons which would explain this difference is that there exists a time lag for CMVs. Due to the higher sensitivity of wide-body aircraft to the business cycle, the trading values for this equipment collapsed in the early nineties. While the SAFE sımulation has no time lag the Avitas Blue Book values are probably delayed because of analyses time plus publıshing time.

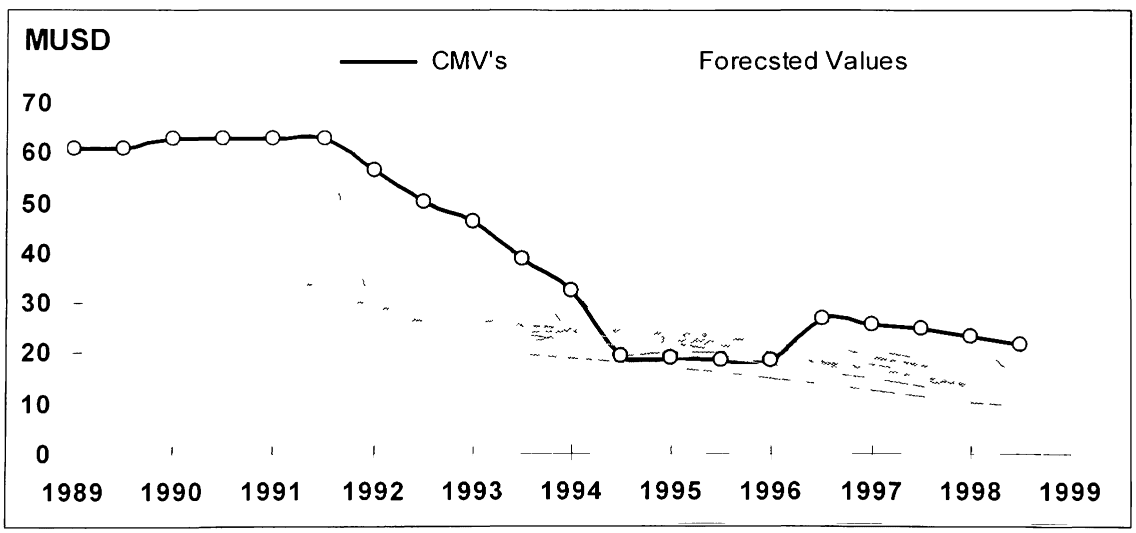


Fıgure 36. B747-200 Avitas CMVs and SAFE Projections.

Taking also into consideration that appraisers need some time before they receive and analyze information about actual transactions, which can also include a few months of negotiations, aircraft evaluation and finalizing legal work, it might be easily a year before the full impact of economic changes is reflected in published current market values. When evaluating the high deviation of the SAFE forecast it is important to keep the time factor in mind. As can be seen in Figure 36, the SAFE forecasts reflect exactly the trends of the CMVs but are 2 years to early. In SAFE the values start to decrease in 1990 wile Avitas' CMVs start to decrease in 1992. The consistent values for the SAFE standard deviations are important since it indicates the same variation for each forecast horizon. Each form of consistency is an advantage in financial risk evaluations. Therefore consistency of the standard deviation needs to be considered as an essential element of a forecasting model evaluation.

In summary the SAFE model shows high accuracy for the narrow-body analysis. The wide-body forecasts are in general much lower than the Avitas CMVs. A publication time lag might be the explanation for the high deviations, since the consistent standard deviation and a qualitative analysis of Figure 36 indicate a good coverage of the business cycle.

4.1.2 Avitas

The Avitas forecast analysis is based on Blue Book values published from 1989 to 1998. For the forecast accuracy evaluation the same criteria as for the SAFE model will be applied. The tables 11 and 12 present the mean of the error and the standard deviation for each aircraft type and forecast horizon. The format is the same as used in the previously conducted SAFE evaluation. As observed before, the average error for the wide-body aircraft is bigger than for the narrow body models.

Table 10

Systematic Error of Avitas Historic Predictions for Different Forecasting Horizons

Horizon	Mean of Error (Avitas)						
Month	B747	A300	DC10	A320	MD83	B737	B757
0	0%	0%	0%	0%	0%	0%	0%
6	4%	10%	8%	2%	2%	0%	2%
12	11%	18%	16%	6%	4%	-1%	5%
18	13%	23%	21%	7%	6%	0%	6%
24	16%	28%	26%	8%	9%	1%	7%
30	20%	34%	32%	8%	11%	3%	9%
36	27%	39%	37%	9%	14%	5%	11%
42	34%	45%	43%	9%	16%	7%	12%
48	41%	51%	48%	9%	18%	8%	13%
54	49%	55%	52%	10%	22%	10%	15%
60	53%	59%	55%	11%	24%	11%	16%
66	57%	62%	59%	14%	27%	13%	18%
72	57%	64%	60%	18%	27%	15%	21%
78	57%	65%	61%	19%	28%	14%	21%
84	56%	66%	61%	21%	29%	14%	22%
90	53%	66%	61%	24%	30%	13%	21%
96	54%	65%	61%	26%	31%	12%	22%
102	54%	65%	61%	27%	32%	12%	23%
108	55%	62%	59%		33%	11%	22%
114	57%	63%	59%		33%	14%	23%
	Wide-body			Narrow-body			

Table 11

Values for One Standard Deviation of Avitas Historic Predictions for Different Forecasting Horizons

Horizon	Standard Deviation (Avitas)						
Month	B747	A300	DC10	A320	MD83	B737	B757
0	0%	0%	0%	0%	0%	0%	0%
6	16%	11%	11%	7%	8%	9%	5%
12	21%	15%	16%	9%	10%	13%	7%
18	26%	17%	18%	10%	11%	14%	8%
24	31%	19%	20%	12%	12%	16%	8%
30	32%	20%	19%	15%	13%	17%	8%
36	31%	19%	19%	16%	13%	17%	7%
42	28%	18%	17%	15%	13%	16%	8%
48	24%	15%	14%	13%	12%	15%	7%
54	16%	11%	14%	12%	10%	13%	6%
60	12%	10%	11%	12%	9%	12%	6%
66	9%	8%	7%	8%	5%	9%	5%
72	7%	5%	5%	3%	5%	5%	3%
78	6%	4%	3%	2%	3%	3%	3%
84	6%	3%	2%	4%	2%	3%	4%
90	4%	3%	2%	3%	2%	3%	5%
96	4%	4%	2%	2%	2%	3%	4%
102	3%	4%	3%		2%	3%	3%
108	2%	1%	1%		1%	4%	2%
114	0%	0%	0%		0%	0%	0%
	Wide-body			Narrow-body			

The standard deviation (Table 11) of the error for Avitas forecasts is only slightly higher for the wide bodied aircraft. While the standard deviation of the error for most aircraft ranges from 10% to 20%, the B757 and B747 have very low and very high standard deviations respectively. The column of the A320 is not complete, because the model chosen is the youngest aircraft of this analysis. The model specified was built in

1991. Different from the SAFE evaluation is that the average error is positive for all aircraft types. Thus, the average of the forecasts for each specific time frame is too high. In the following graphs the results are summarized for wide-body and narrow-body aircraft (Figure 37).

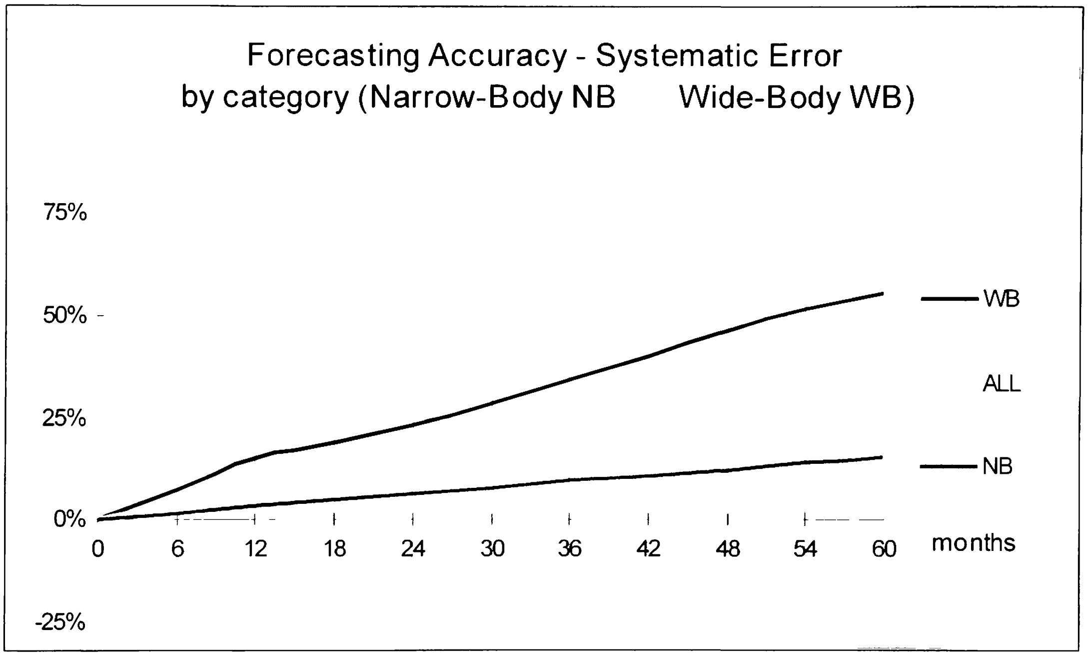


Figure 37. Avistas Forecasting Accuracy.

As could be expected, the error for the wide-bodies is higher than for the narrow-bodies. Interesting is that the average of the errors increases with the forecasting horizon expanding. For the SAFE model the error decreased for higher forecast horizons. While the average error is increasing the standard deviation (Figure 38) is decreasing for longer forecast horizons. Although similar for the narrow-body aircraft, the standard deviation for wide-bodied aircraft is much smaller for the Avitas errors in comparison to the standard deviation of the SAFE errors for wide-bodied aircraft.

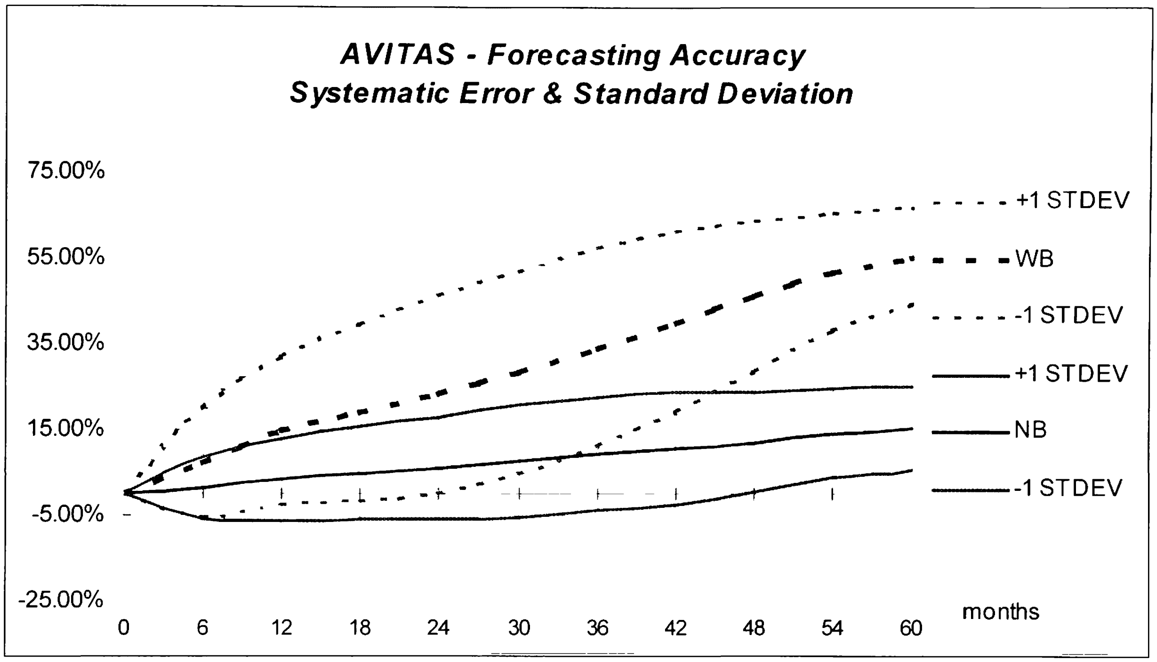


Figure 38. Avitas Systematic Error with +/- One Standard Devation.

The B747 is chosen in order to evaluate the congruence of the Avitas forecasts and the business cycle. In Figure 39 it can be seen that the forecasts of Avitas are ultimately base values due to the straight-line characteristic. The downturn of the airline industry in the early nineties, which caused demand for high capacity equipment to drop dramatically, is not captured in these forecasts. Before 1992 and after 1995, forecasts and CMVs are close together. During the time of B747-200 values plunging, 1992 to 1995 the forecasted values are considerably inflated.

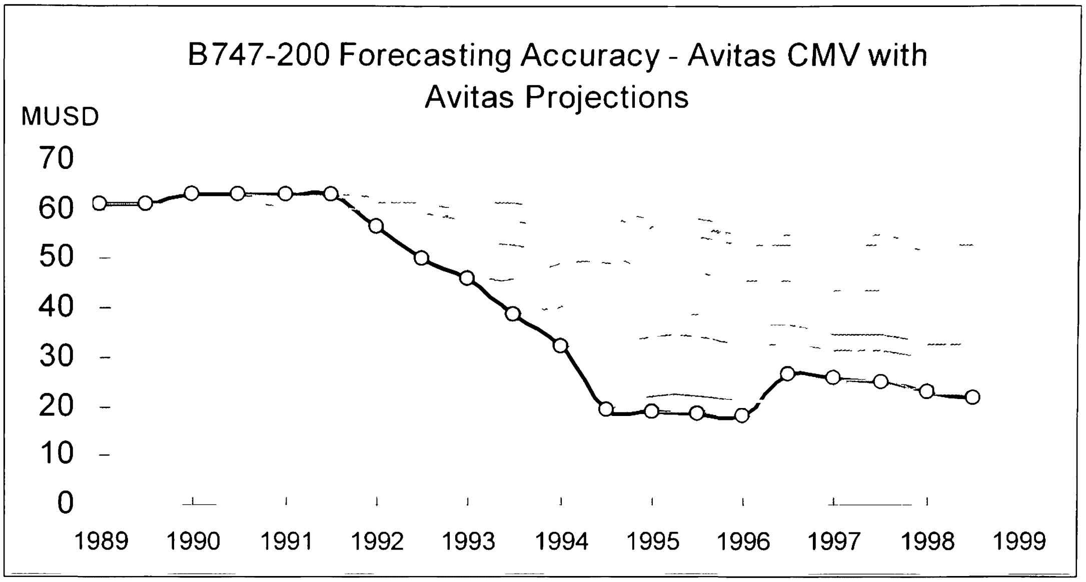


Figure 39. B747-200 Avitas CMVs and Avitas Projections.

Conclusively, Avitas forecasts for narrow-body aircraft values reveal a relatively good accuracy. Standard deviation and systematic error are mainly below 10%. However, the error is getting larger with the forecast horizon expanding. The same pattern is found for wide-body value forecasts. Though the error is increasing faster for the wide-body forecast. Interesting is, that the standard deviation for the wide-body value forecasts is very low compared to the SAFE wide-body forecast. An explanation for this phenomenon might be that the straight line characteristic of the forecast results in more consistent deviations. The important difference between the SAFE and the Avitas forecast technique is that in the SAFE forecasts the up and down swings of values are incorporated. The impact of the demand and supply imbalances in the market is applied to the evaluation of aircraft values. How good a forecast can be if the assumptions are correct, can be seen in Figure 40.

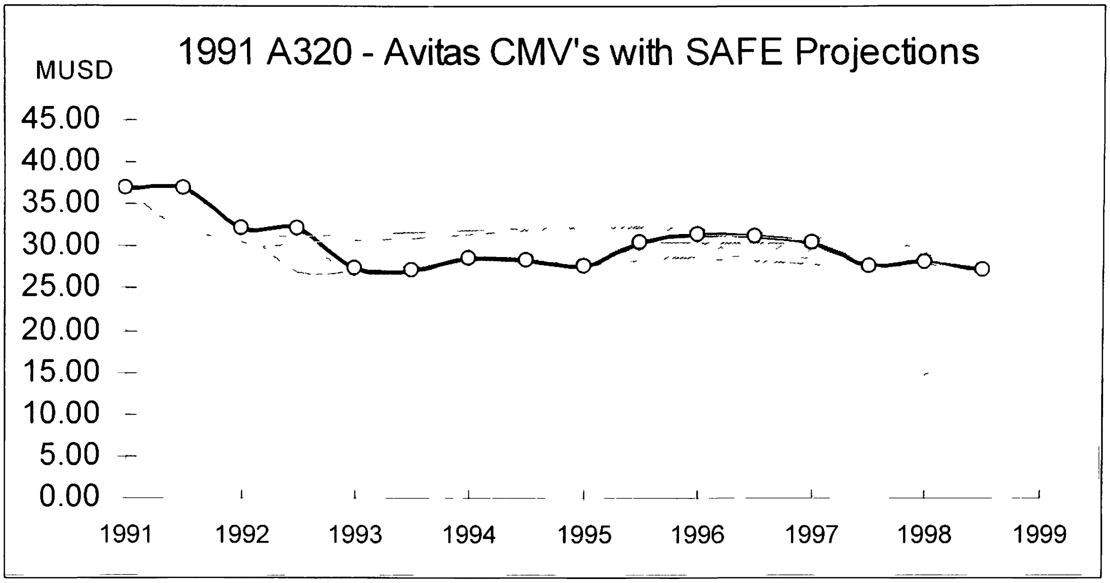


Figure 40. A320 Avitas CMVs with SAFE Projections.

4.2 Disunity in the appraisal industry

Who is right when it comes to aircraft values? This question can not be answered here. But it is possible to evaluate the appraisal industry as a whole. We said that current market values vary significantly and that the appraiser's values can be seen only as a benchmark. Pierre Casau, a member of Credit Agricole says: "We do not rely anymore on appraisers' values – they are just an indication" (O'Conner, 1994). As the following figure shows, the current market value estimates of several appraisers for the MD-83 vary from $15.66 million to $21.55 million (Figure 41). That is a high range for a relatively often-traded aircraft. A standard deviation of $0.76 million representing 10.2% of the mean is, from an investor's point of view, not very promising.

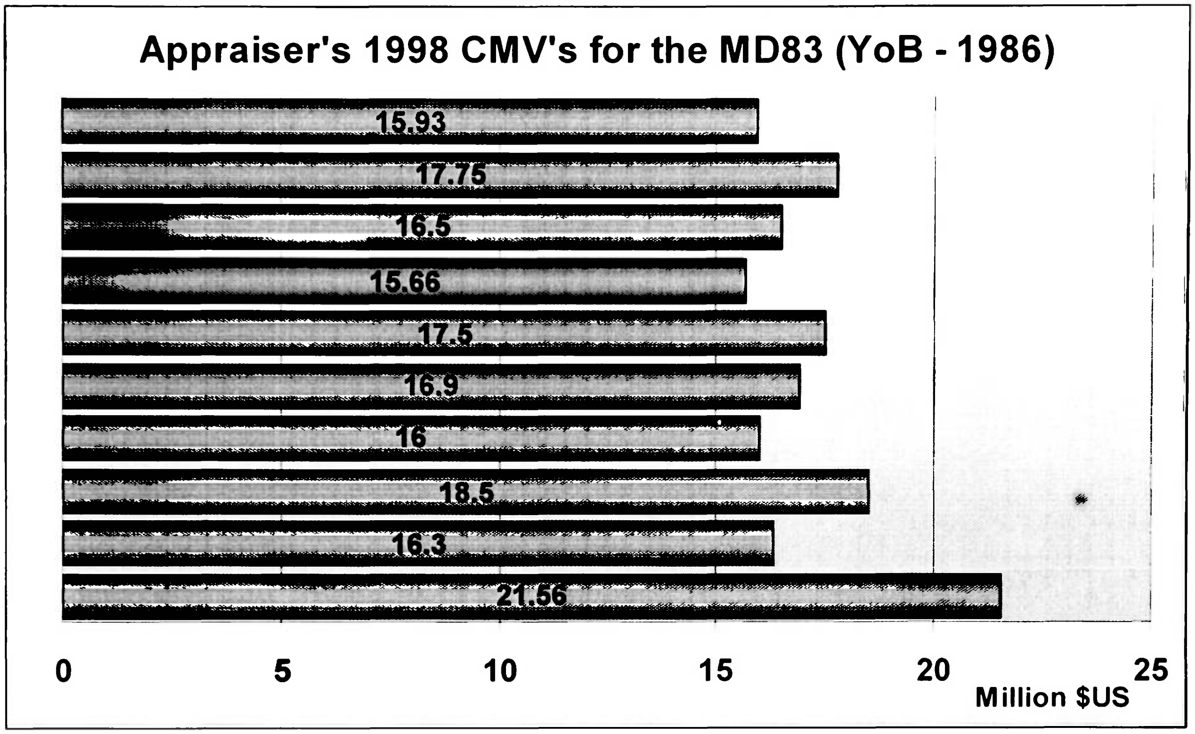
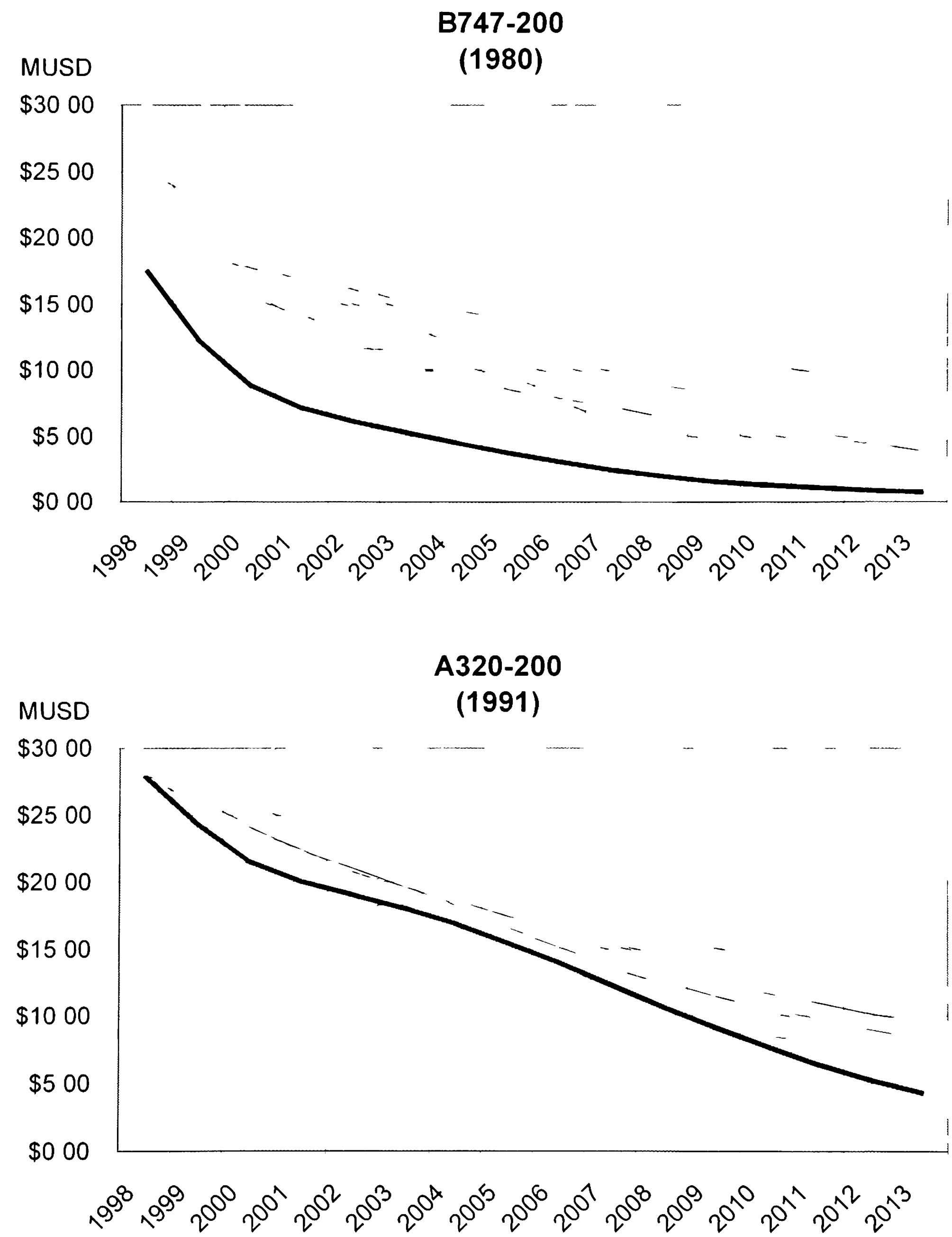


Figure 41. Appraiser's Current Market Value Disagreement.

Eleven of the most recognized appraisers in the industry provided the requested information. It must be mentioned that the data provided by the appraisers also include base values despite the request for trading values. But since the appraisals received are the same customers are buying, no differentiation was made in the analysis. As was expected after the historical forecasting accuracy analysis in the previous chapter, the author found that depending on the aircraft type forecasted values showed more or less variance. Aircraft more volatile and stronger correlated to the industry cycles are more difficult to evaluate than aircraft with less cycle sensitivity. Plotting the values of an old wide-body and young narrow-body, it can be clearly seen that the forecasted values for the A320 are closer and more parallel than for the 747 (Fιgure 42)   The bold lιnes runnιng lower than the rest are projectιons calculated by SAFE.



Fιgure 42.   Wιde-Body and Narrow-Body Value Forecast

The SAFE values are added in order to show the contrast to the rest of the appraising industry. The both graphs represent the lowest and the highest standard deviations of all aircraft included in the survey. The forecasts for the remaining aircraft all show less harmony than the A320 but do not spread more than the B747 projections. Figure 43 displays the mean and ± one standard deviation for the two aircraft types.

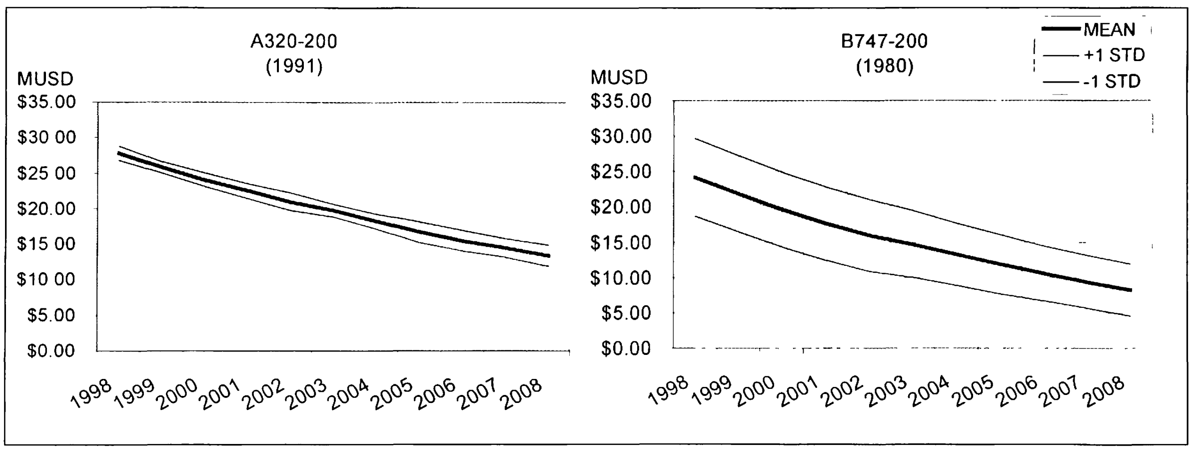


Figure 43. Comparison of Mean and +/- One Standard Deviation of Two Aircraft Included in 1998 Appraiser Survey.

Two appraisers submitting extremely high values were taken out of the analysis, since they might have represented especially equipped aircraft. The goal of the analysis is to show the disunity in the appraisal industry, but not any misleading extremes. From Figure 42 not only the disharmony of the appraisals can be found, but also the forecast technique. Besides the SAFE forecast, there is only one line reflecting the typical up and down swings of aircraft values. Although asked for the most likely trading values, some appraisers might have either send only base values or they neglect cyclicality in their analysis. Without the consideration of the business cycle, appraisers underestimate the importance of short-term and long-term aircraft value fluctuations for the financial industry? While Airclaims and IBA incorporate some cyclicality in their forecasts only Paul Leighton's value show significant swings. The following graph (Figure 44) shows Paul Leighton's forecasts for the seven aircraft analyzed.

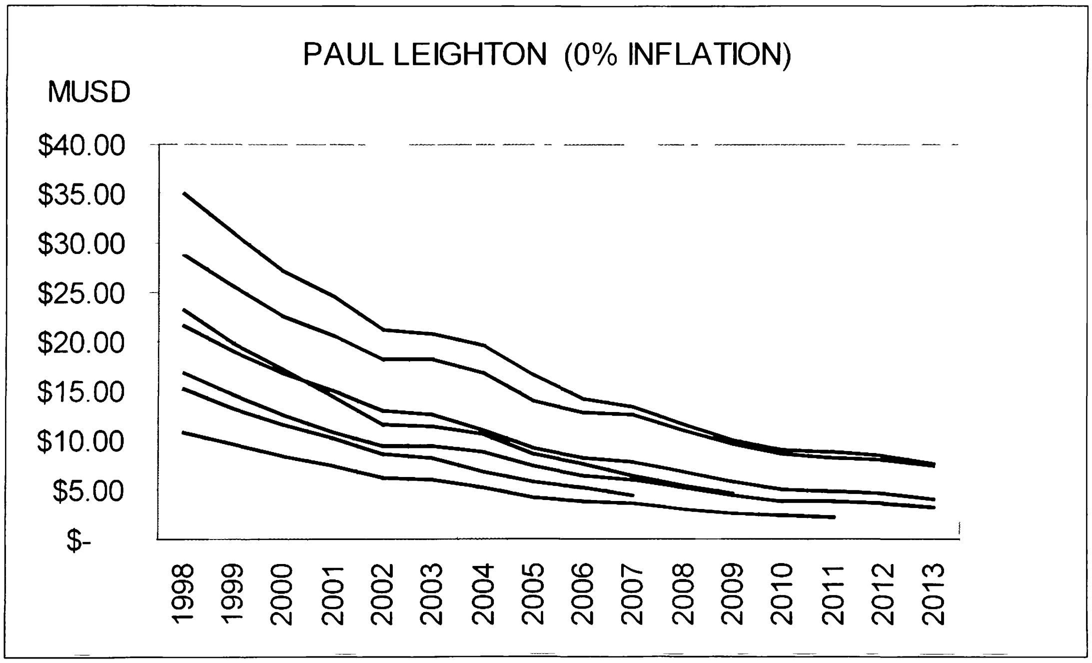


Figure 44. Survey Results From Paul Leighton.

Mr. Leighton foresees less demand in the years 1999 and to 2002 followed by increased demand in the years 2003 and 2004. For 2007 and 2008, there appears to be another upswing in the forecasted aircraft values, indicating also increased demand. This type of forecast is very valuable for airlines and investors in order to evaluate the timing and risk of investment decisions. However, it would be important to know also the historic forecast accuracy to have an understanding of the probability of the forecast to be correct.

The majority of the appraisals received were straight-line forecast represented by one example in Figure 45.

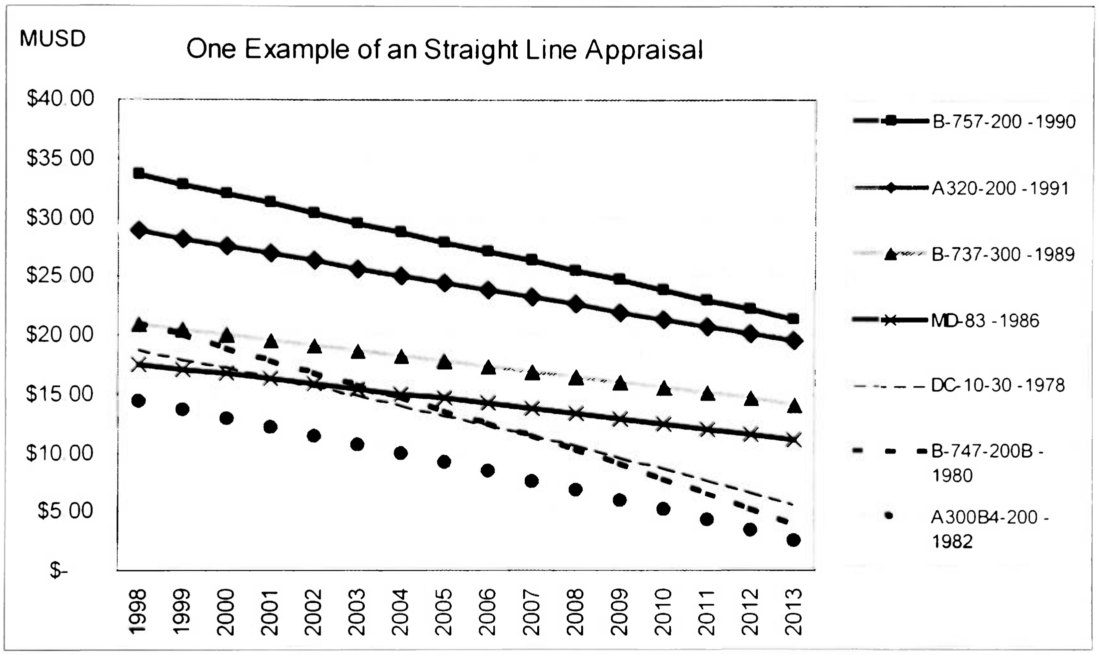


Figure 45. Example of Straight Line Survey Results.

The following graph (Figure 46) exhibits the standard deviations, which reflect the appraiser's degree of disharmony, for the seven aircraft. The most variation in current and forecasted market values exists for the B747-200. Interesting is that the appraisers show disharmony in their appraisals for the B757, which is a narrow body aircraft and frequently traded. There are two possible explanations for the high standard deviations. On the on hand, some appraisers could have neglected that the values were requested for an ETOPS certified B757. On the other hand, the B757 is gaining popularity as a candidate for cargo conversion. A reason for that is the phase out of B727 in the light of the emerging Stage III noise emission requirements. The forecasts of the values for the other two wide-bodies, the A300 and the DC-10, confirm a more unified opinion of the appraisers. As was expected, the predicted future values of the three most popular narrow-bodies, the MD83, the B737 and the A320 have very similar standard deviations, close to the $1 million level.

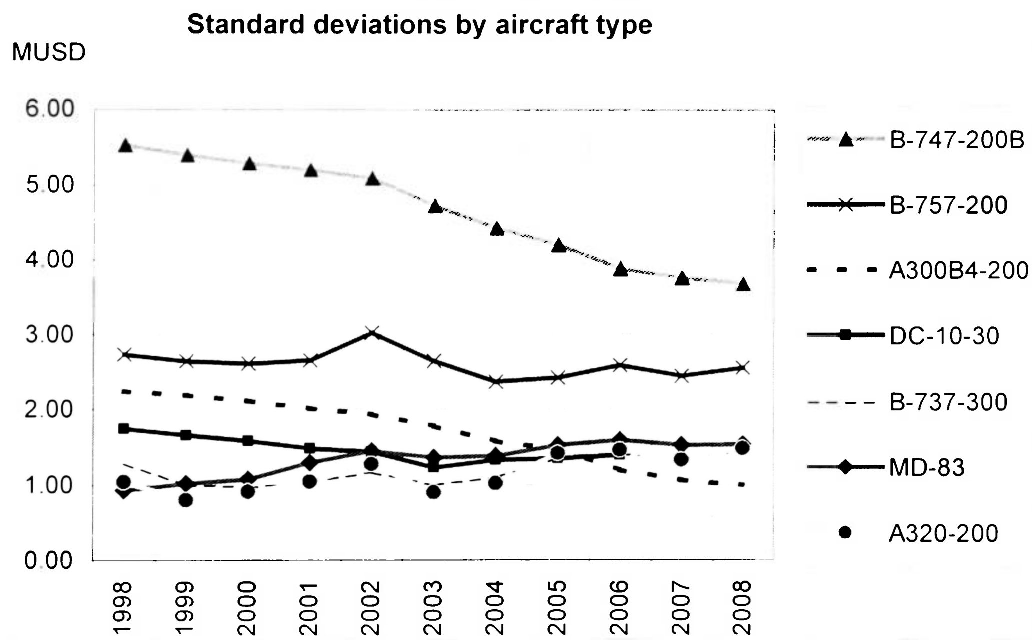


Figure 46. Standard Deviation of Survey Results by Aircraft Type.

The charts of the value forecasts for each individual aircraft can be found in the appendix. The results of the future value survey can be summarized in one word: Disharmony. The current market values for the B747-200 manufactured in 1980 ranged from $20 to $37 million. The 10-year predictions for the year 2008 ranged from as low as

$4 million up to $16 million. Although the appraisers might have assumed different specifications of the aircraft for their appraisal, these variations are from an investor's perspective intolerable. In favor of the appraisers, it is important to mention that the high disharmony of the B747-200 was a unique case in the survey. For the other aircraft types, the variance of the forecasted values was much lower.

4.3 Model / Sensitivity analysis

Having analyzed the forecast accuracy of historic data and demonstrated a high disharmony in the expectation of future values, in this chapter the problems of the modeling process are presented. The results of a scenario analysis show the impact of variations in the main variables used to determine an aircraft's value. The second part of this chapter presents the result of a value determination for a B737 with the application of the NPV technique. The purpose of presenting this aircraft value determination is to show the difficulties involved in the application of the NPV model. The forecasting date chosen is 1985 so that it is possible to use historic operational data for the first half of the first 14 years (1985 to 1998) and forecasted data for the last 16 years of operation for a B737-300. The appliance off actual historic data is supposed to increase the accuracy of the modeling process.

The first step in the analysis is the determination of historic and future available seat miles (ASMs). ASMs for the US airline industry are published in the Airline Monitor by aircraft type. By dividing the total annual ASMs of B737 by the number of B737's operated, the annual ASM for one aircraft can be found (Table 12). From the historical ASMs the future ASMs can be extrapolated. Figure 47 shows the trend line, which describes the future ASMs. The reduction of utilization for old equipment, which could only be estimated, is incorporated in the regression equation. An example for reduced utilization is United Airlines B737-200 fleet. The utilization for this aircraft type was 9.28 hours in 1986, 8.09 hours in 1992 and 7.40 hours in 1996 (IATA, 1987, 1993, 1997). In 1992 the average age of the B737-200 fleet was 20.5 years (World Aviation Directory, 1994). Therefore, for the last ten years of operation (2005 to 2015) annual ASM for the B737-300 calculations decrease.

Table 12

Available Seat Miles for a Single B737

Airline Monitor June 1997			
	ASM of B737 US Industry	Number of B737	ASM for 1 B737
1985	3,921,900,000	25	156,876,000
1986	14,737,800,000	83 6	176,289,474
1987	28,621,500,000	169 2	169,157,801
1988	43,233,000,000	251 5	171,900,596
1989	54,328,300,000	313	173,572,843
1990	61,058,400,000	353 5	172,725,318
1991	63,031,800,000	373 7	168,669,521
1992	64,455,200,000	370 8	173,827,400
1993	65,647,600,000	380 8	172,393,908
1994	69,229,700,000	402 6	171,956,533
1995	75,225,100,000	439 5	171,160,637
1996	82,167,300,000	462 2	177,774,340
1997	87,663,900,000	481 3	182,139,830

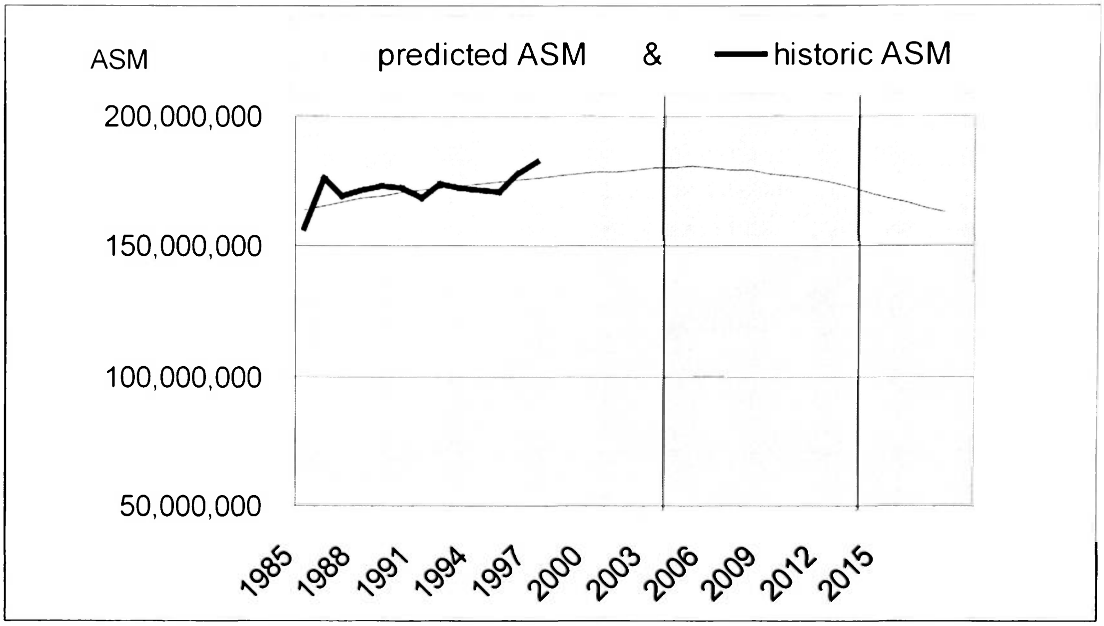


Figure 47. ASM forecast for a B737 built in 1985.

The second step in the analysis is the examination of historic and future cash flows. The annual cash flow is the difference between revenues and costs. The Air Transport Association of America (ATA) publishes the historic revenues per ASM and the expenses per ASM for the US industry. Trendline regression aims relative good results for the expense and revenue forecasts (Figure 48). R-squared of 95.1% and 88.9% are considered sufficient for the purpose of this analysis. While the cyclical characteristic of the industry is neglected, it is assumed that in light of the long forecasting horizon the straight-line forecasts represents the average of actual future values. In order to test this assumption, actual historic data and calculated data will be used as input for the NPV-calculations.

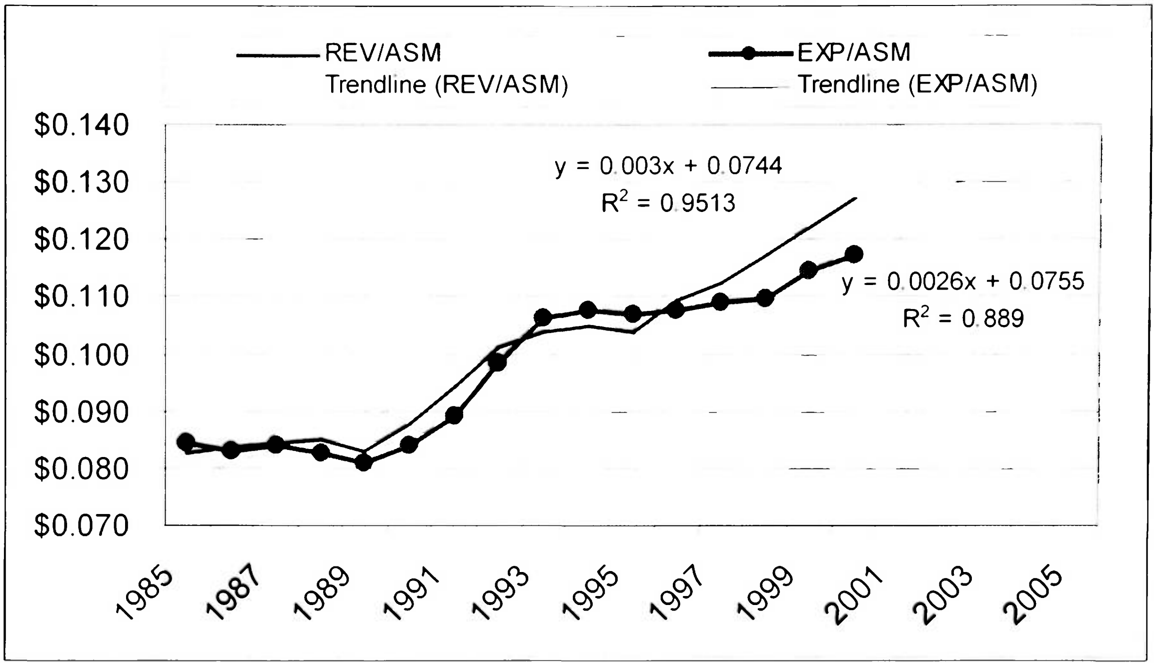


Figure 48. US-Airline Industry Revenue and Expense Trends.

Despite lower utilization of narrow-body equipment and higher fuel cost due to higher cycle-hour ratios, the author assumes the direct operating cost per ASM for the B737, a new aircraft in 1985 to be very close to the industry average direct operating cost (Roberts, 1995). Therefore the average expenses per ASM from the ATA data does not require any adjustment. However, revenues per ASM vary significantly by stage length.

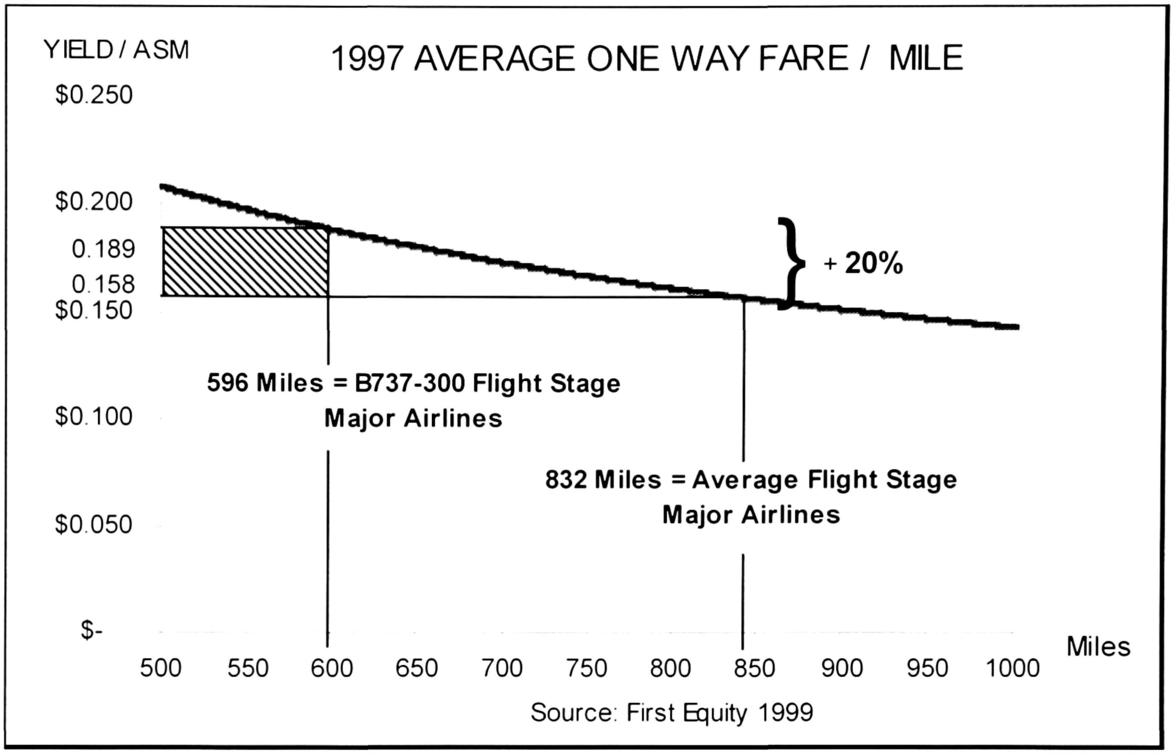


Figure 49. Graphical Determination of Revenue per ASM for B737.

For B737-300 operations, averaging 596 miles stage length, the revenue per ASM is 20% above industry average (Figure 49). For the one-way ticket, the revenue per ASM is 15.8 cents. B737-300 stage lengths, which are on average 236 miles shorter than the 832 miles average US airline stage length the revenue per ASM is 18.9 cents (First Equity). Although one way fares are used for the determination of the 20% revenue increase for shorter stage lengths in B737 operations, the author assumes that the same increase in percentage is valid for round trips. For the final aircraft value determination this revenue increase factor, called RIF from now on, will be critically evaluated in a subsequent sensitivity analysis.

Besides the discount rate, all data required for the NPV-analysis is available. A discount rate of 12%, representing the average cost of capital for airlines, is applied to the model (Morrel, 1997). The discount factor is also examined in the subsequent sensitivity analysis. The following two tables (Table 13 and Table14) exhibit the variables used to find the annual cash flows. The summation of the discounted cash flows results in the NPV of the cash flows, representing the aircraft value. In Table 13, the actual data (expenses, revenues, ASM) are used for the years 1985 to 1997. At a discount rate of 12%, the value of the B737-300 is $26.5 million. The actual value for a new B737-300 in 1985 was according to the Airline Monitor $25,6 million. In order to find the impact of using the calculated straight-line data versus actual data the NPV was calculated with these data in Table 14. Applying the value of the B737 with theoretical data only aimed o $25.2 million. Although this one result has no statistical relevance, it still shows that in this specific case there is no significant difference between using actual and theoretical data.

Table 13

NPV-Model for 1985 B737 with Actual Operating Data

			DISCOUNT RATE =		12%
				NPV =	**$26,449,994**
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
	$	$	$		
1985	0 085	0 098	0 083	156,876,000	$ 2,413,022
1986	0 083	0 096	0 081	176,289,474	$ 2,583,484
1987	0 088	0 101	0 084	169,157,801	$ 2,872,681
1988	0 094	0 108	0 089	171,900,596	$ 3,301,566
1989	0 101	0 116	0 099	173,572,843	$ 3,096,382
1990	0 104	0 119	0 106	172,725,318	$ 2,239,549
1991	0 105	0 121	0 108	168,669,521	$ 2,237,853
1992	0 104	0 119	0 107	173,827,400	$ 2,142,112
1993	0 110	0 126	0 108	172,393,908	$ 3,155,039
1994	0 113	0 129	0 109	171,956,533	$ 3,499,169
1995	0 117	0 135	0 110	171,160,637	$ 4,251,281
1996	0 122	0 140	0 115	177,774,340	$ 4,581,802
1997	0 127	0 146	0 117	182,139,830	$ 5,300,024
1998	0 124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573

Table 14

NPV-Model for 1985 B737 with Generated Operating Data

			DISCOUNT RATE =		12%
				NPV =	**$25,165,345**
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
	$	$	$		
1985	0 087	0 099	0 086	162,536,374	$ 2,173,924
1986	0 089	0 103	0 089	164,451,708	$ 2,303,968
1987	0 092	0 106	0 092	166,251,564	$ 2,434,754
1988	0 095	0 109	0 094	167,935,941	$ 2,566,061
1989	0 098	0 113	0 097	169,504,840	$ 2,697,670
1990	0 101	0 116	0 100	170,958,260	$ 2,829,359
1991	0 104	0 119	0 102	172,296,201	$ 2,960,910
1992	0 107	0 123	0 105	173,518,664	$ 3,092,103
1993	0 110	0 126	0 108	174,625,649	$ 3,222,716
1994	0 113	0 129	0 110	175,617,155	$ 3,352,531
1995	0 116	0 133	0 113	176,493,182	$ 3,481,328
1996	0 118	0 136	0 116	177,253,731	$ 3,608,886
1997	0 121	0 139	0 119	177,898,801	$ 3,734,985
1998	0 124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573

Making some substantial assumptions in a model requires a critical analysis of the input variables. In the following sensitivity analysis the impact of changes in the discount rate and the RIF are examined. Figure 50 exhibits the results of the sensitivity analysis. If the discount rate is constant at 12 % and the RIF is changed, the aircraft values vary from $11.5 million to $34million. Thus shows a very high impact of the RIF on the aircraft's value in the model used. If the RIF is constant and the discount rate is altered, the values vary from $22.3 to $38 million. The discount rate, as can be expected for a 30-year time frame, is also a main factor in the determination of the aircraft's value.

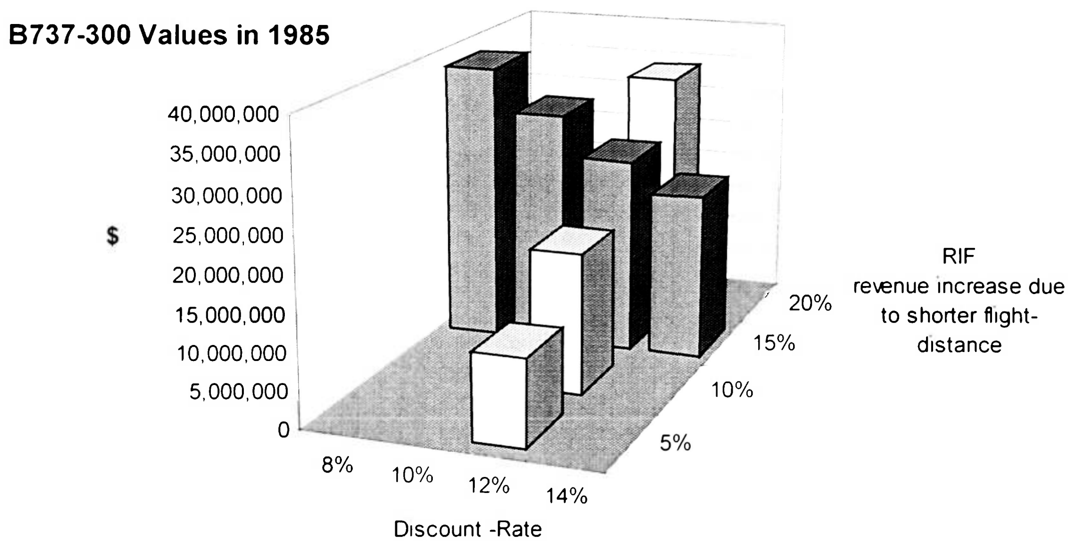


Figure 50. B737 Values for Different Scenarios.

It can be summarized that it is possible to calculate the value of an aircraft relative precisely. Forecasting the required variables by trendline-regression aims in the current analysis good results. However, the aircraft value is very much determined by two variables. The discount rate and the revenue increase factor applied for shorter flight stages. These two variables have so much impact that a little variance can cause significant changes ın the aircraft value. Therefore, the application of the NPV analysis requires a thorough understanding of the ınput vanables.

Since the model analyzed above ıs relative sımple, not all variable determinıng an aircraft's value could be analyzed. Mr. Edmund Greenslet generously provided a more sophisticated NPV-model (Table 15).

Table 15.

Edmund Greenslet NPV-Model.

B737-300	PRESENT VALUE MODEL						
	For an Aircraft whose Year of Build is				*1989*		
Age ın Years:	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Calendar Year:	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Yield	13 9	14 3	14 8	15 2	15 7	16 1	16 6
Passenger Rev	15,56	16,02	16,50	17,00	17,51	18,03	18,58
Cargo & Other	467	481	495	510	525	541	557
Total Revenue (000)	**16,028**	**16,508**	**17,004**	**17,514**	**18,039**	**18,580**	**19,138**
Flyıng Labor / Block	370	383	396	410	425	439	455
Fuel per Gallon -	55 8	57 8	59 8	61 9	64 0	66 3	68 6
Fuel / Block	419	433	448	464	480	497	514
Maıntenance /	87	90	93	193	200	207	428
Total / Block	876	906	938	1,06	1,10	1,14	1,39
B H Cost -	3,15	3,26	3,37	3,84	3,97	4,11	5,03
Mkt , G&A	7,21	7,42	7,65	7,88	8,11	8,36	8,61
Ownershıp	2,80	2,80	2,80	2,80	2,80	2,80	2,80
Total Costs (000)	**13,172**	**13,499**	**13,836**	**14,532**	**14,903**	**15,285**	**16,452**
Pretax Profit	2,85	3,00	3,16	2,98	3,13	3,29	2,68
Pretax Margın	17 8	18 2	18 6	17 0	17 4	17 7	14 0
Aircraft Value: k=12%							
Basic Value: $(000)	**27,134**	**26,754**	**26,220**	**25,518**	**24,989**	**24,302**	**23,923**

His model incorporates the various cost and revenue variables. In this version of the model 1993 data are used as base-values. These variables are altered according to escalation formula for previous and succeeding years. Table 15 exhibits the cash flow determination sheet for the first 7 years of a B737 build in 1989. The last row contains the NPV of future net cash flows representing the value of the aircraft. This model enables a scenario analysis since a lot of input variables are required. The variables chosen can be categorized in two groups:

Revenue: Utilization, Load-factor, and Yield

Expenses: Labor, Fuel, Maintenance, and Interest

The different scenarios are applied to two aircraft types, a B737 build in 1989 and a B747 build in 1980. In order to use a maximum operational life for both types 1989 is the date of the value determination. The scenarios chosen were an increase in each variable by 5%, 10% and 15%.

For each revenue-determining variables each scenario resulted in the same impact on the aircraft value. In the model a percentual changes in either of the variables utilization, load-factor, or yield results in the same change in total revenue. Therefore in Table 12, only one figure is representing the impact of these three variables. Due to an increase in revenue, the variation in the value is positive, too. Similar to the result of the previous chapter, relative small changes in revenue increase the value significantly. Only 5% change in revenue, result in 18.24% increased value for the B737 and 22.69% for the older B747. Interesting, the value increases are proportional to the increase of the input variables.

The increase in the cost variables caused the aircraft values to decrease. Compared to the impact of the revenue variables, changes in the cost variables are moderate. Labor, fuel and maintenance cost increases cause aircraft values to drop from 2.53% up to 9.77% for the B737. B747 values decline between 3.1% to 16.51%. From these three variables, the fuel price alterations have the strongest influence on the values. The changes of the discount factor appear to result in less variation of the aircraft value. The reason is that the changes are lower and the results are presented as percentage. For the B737 a change an increase of the discount facto to 13.8 % causes the value to drop from $27 million to $23.8 million. The variations of aircraft values due to the increased discount factors are not proportional to the change rate. For the B747 values the effect of the discount rate changes are more m0derate since the aircraft type was build in 1980 and is according to the model only operated for another 15 years.

Table 16

Scenario Analysis Results

Impact on value in 1989			
B-737-300 1989	Variables changed by 5%	10%	15%
	Value changed by		
Utilization Loadfactor Yield	18 24%	36 49%	54 73%
Labor	-2 88%	-5 76%	-8 64%
Fuel	-3 26%	-6 51%	-9 77%
Maintenance	-2 53%	-5 05%	-7 58%
discount factor k	-4 42%	-8 50%	-12 28%

Impact on value in 1989			
B-747-200 1980	Variables changed by 5%	10%	15%
	Value changed by		
Utilization Loadfactor Yield	22 69%	45 39%	68 08%
Labor	-3 12%	-6 24%	-9 36%
Fuel	-5 50%	-11 01%	-16 51%
Maintenance	-4 80%	-9 61%	-14 41%
discount factor k	-3 28%	-6 39%	-9 33%

The main findings from the scenario analysis are that changes of revenues cause the most variation in the aircraft value. The relative small profit margin in the airline industry is another indicator for this result. Small changes in load-factors can result in operating below the break-even load factor for the airlines. Similar percentual changes in direct operating cost or capital cost cause less variation in aircraft values. An explanation might be that the direct operating costs represent in general less than 50% of total cost. Therefore, the values are less sensitive for changes in the direct cost variables.

5 Conclusion

The growing aircraft leasing industry is the driving force for research related to aircraft values. In 1996 only 16% of the airlines owned all their fleet. The number of aircraft leased grew annually by 13% in the last two decades (Holden, 1998). The growing number of participants, financing aircraft through capital market transactions rely heavily on aircraft value appraisals. Aircraft appraisals and future value forecasts become more and more important. The market trends can be regarded as the initial motivation for this study.

The net present value (NPV) concept is widely used for capital asset valuations. The examination of the NPV method application to aircraft valuation was the objective for this research paper. The goal was to demonstrate factors limiting the quality of NPV methods. In order to find these limitations the process of aircraft valuation was analyzed. Besides looking at the techniques used by different appraisers, an evaluation of the actual situation in the appraisal industry was performed.

The industry evaluation was based on two methods. First the forecast accuracy was analyzed. Due to limitations in the availability of data, the forecast accuracy analysis was conducted for two models. Historic forecast data were available form Avitas. In order to evaluate the forecast accuracy, predicted values in the past were compared to current market values published bi-annually in the Avitas Blue Book. Data was available for seven aircraft types. The same analysis was performed for data from Credit Loynnais/PK Airfinance (CL/PK). CL/PK has developed a model with the acronym

SAFE (Statistical Aircraft Financing Evaluation). The software could be used to simulate historic forecasts for the same aircraft types used in the Avitas analysis. Knowing the deviations from the forecasted values to the historic actual market values, the average error for one, two and more years forecast horizons could be calculated. Also the standard deviation for each forecast horizon was determined.

The Avitas results showed high deviations between the forecasts and actual values. For narrow-body jets, the systematic error was moderate and the forecast accuracy for wide-bodies was very low. Avitas systematic error increased gradually with the extension of the forecast horizon. The average narrow body value forecast error reached about 20% for a 5 year forecast horizon. For wide-bodies the average value forecast error was over 50% for a 5 year forecast horizon. The standard deviation for the wide-bodies ranged from 11% to 24% and for the narrow-bodies it ranged from 6% to 14%.

The SAFE forecasts showed less deviation from the actual values than Avitas' forecasts. The Narrow-body forecasts were close to the actual results and the systematic error was consistently around 10% for the forecast horizons of 1 to 5 years. For the wide-bodied aircraft, the average errors reached up to 40%. With the extension of the forecast horizons the systematic errors became decreased slightly. The average errors were mainly negative which represents a conservative forecasting policy since the future values were under estimated. This can be explained because CL/PK as a financial institute, is risk averse and applies a more conservative assumptions to its' model. The standard deviations for the wide bodies were consistently at 40%, which is very high. For the narrow-bodies the standard deviation was much better and barely exceeded 5%.

The overall result of the forecasting accuracy analysis is that the forecast deviates considerably from the actual values. Only the narrow-body forecasts can be deemed acceptable. The values forecasted by SAFE were so much lower than Avitas' actual historic Blue-Book values because the starting points of the forecasts in SAFE are already much lower. One reason for this is the Blue Book values are higher due to a publication time lag whereas the SAFE values directly correlate to the airline cycle. The knowledge of historic forecast accuracy and confidence intervals would guide investors in the evaluation of risk and rewards. Usually today's appraisals do not provide information about their historic forecast performance. The following statement backs up the previous result. "Appraiser estimates of future values are of limited use in financing aircraft over ten to fifteen year terms" (Holden, 1998).

The second concern regarding appraiser's forecast quality is the results display a large spread. When asked for future values for 7 aircraft, exactly specified, the appraisers responses showed a high degree of variation. The value of the appraisers exhibited a standard deviation between $1 million and $5.5 million. This result coincides with a GE Capital Aviation Services study, which found: "Future value estimates for a 1992 B73-300 vary by over two to one" (Holden, 1998).

Another crucial finding from the survey was that most appraisers neglect that aircraft values are highly correlated to the airline's business cycle. Most appraisers publish only straight-line value depreciation patterns. In Airclaims' and IBA's forecasts, moderate swings could be recognized. It was only Paul Leighton, who incorporates cyclicality in his forecasts. Leighton's up and down swings match the one's predicted by CL/PK's SAFE model.

The third part of the analysis was concerned with NPV models and the impact fluctuations in variables. By applying industry average operating revenue and cost data, the net cash flows for the economic life of a B737-300 were predicted for an operating period from the year 1985 to 2015. Applying a revenue increase factor for shorter operating stage length of B737's and a discount factor of 12%, an aircraft value of $25.2 million was determined. Using actual data for 1985 to 1997 and regression data for 1997 to 2015 the value was slightly higher, $26,4 million.

From the sensitivity analysis it could be learned that changes in both, the discount rate and the revenue increase factor have significant impact on the aircraft value. The changes were significant. This means that the net cash flows, predicted for 30 years are less reliable. Further research is required to find if the same results can be found for different aircraft types. A scenario analysis performed with a more sophisticated model, provided by Edmund Greenslet, the editor of The Airline Monitor, revealed the impact of changes in operating variables. The variables analyzed were load-factor, utilization, yield, labor cost, fuel cost, maintenance cost and the cost of capital. Examining, a B737-300 and a B747-200, it was found that changes in load-factor, utilization or yield had the highest impact on the aircraft values. A 5% change in one of these variables resulted in 18.2 % and 22.7% changes in value for the B737 and B747 respectively. The aircraft values were less sensitive for changes in the cost variables labor, fuel, maintenance or capital than for changes in the previous mentioned revenue determining variables. Changes of 5% in one of these factors resulted in variations of the value in the range of 2.2% to 5.5%. Higher changes resulted in proportionally higher variations in values.

During the work on this project, the need for further research was discovered. An analysis should be conducted in regard to exchange rates. First there might be a correlation between a weak dollar and the demand in countries outside the US. A weak dollar reduces the price for a buyer in another country. Such a study could also examine the impact of the single European currency and changes in the European tax legislation. Also, the expected operating time for modern jet aircraft should be addressed in future research. What is the impact of new materials, such as composites, and new technologies, such as fly-by-wire controls? What is the trend in maintenance cost going to be when today's new aircraft reach 20 or 25 years of age? Another interesting question is the impact of alliances on aircraft values. Is equipment going to be purchased in bulk and can capacity be shifted easier from region to region in case of demand variations? The topic aircraft value forecasting is as complex as the aviation industry and bears a lot of research potential for the future.

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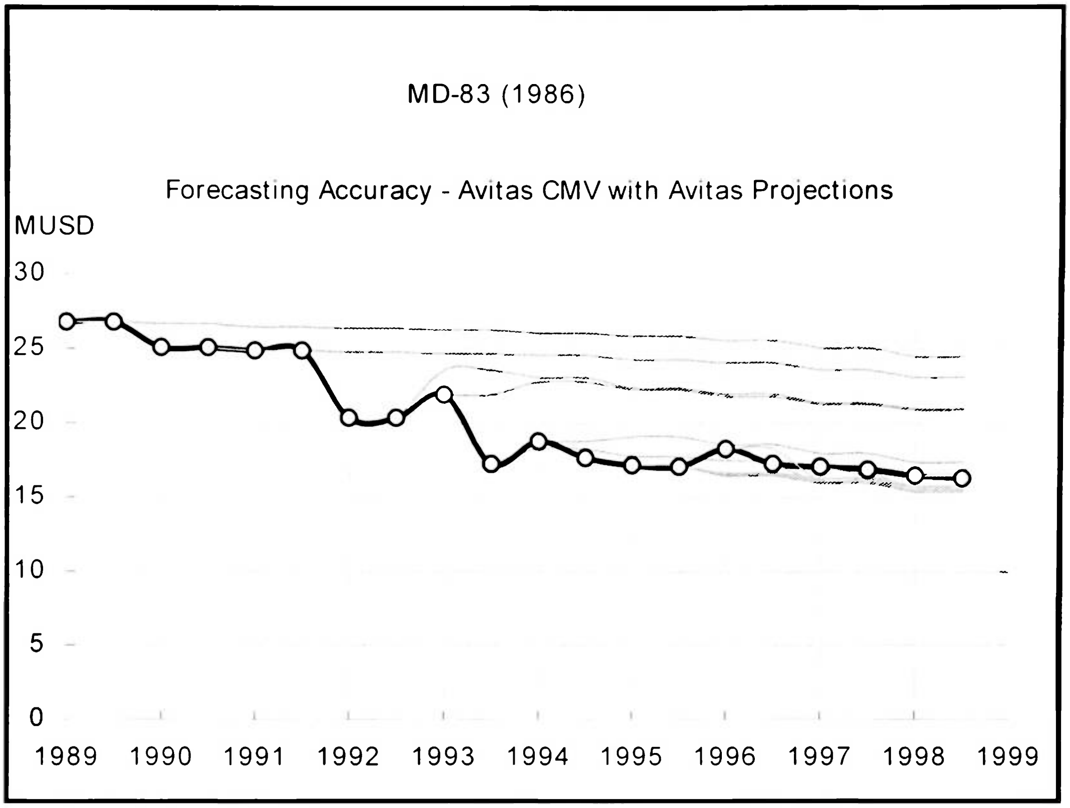
Appendix A

Forecast Accuracy


MD-83 (1986)
Forecasting Accuracy - Avitas CMV with Avitas Projections
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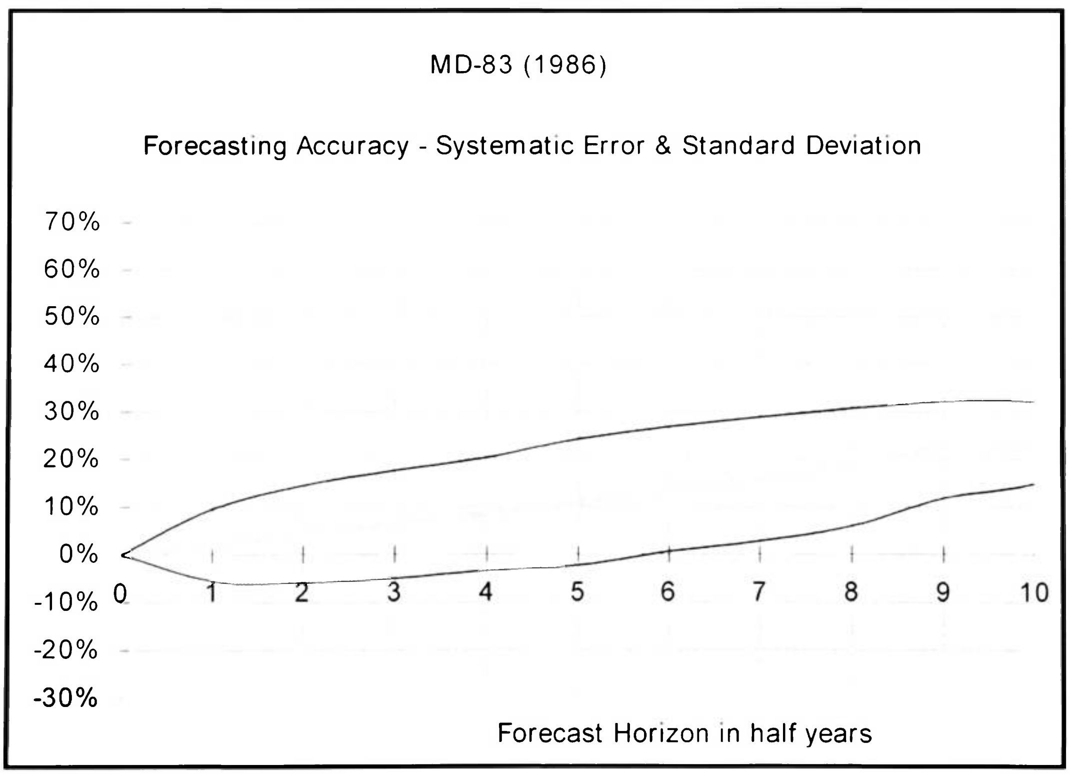
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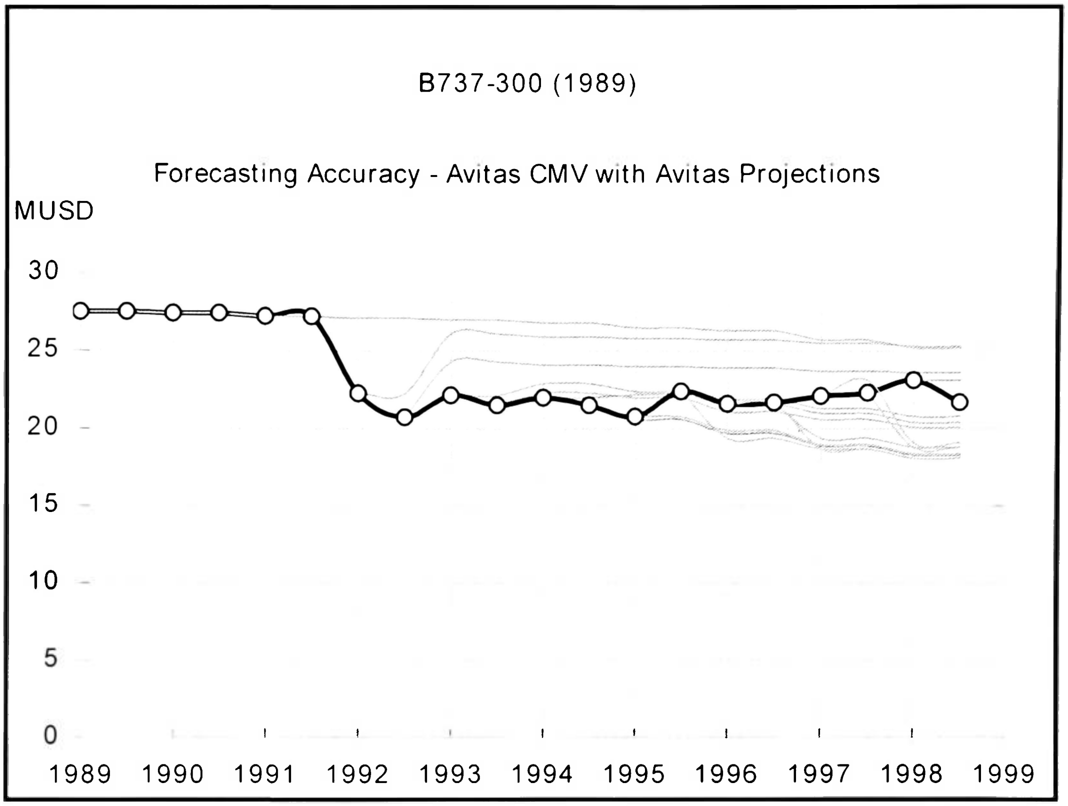
Forecast Horizon in half years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Forecasting Accuracy - Avitas CMV with Avitas Projections
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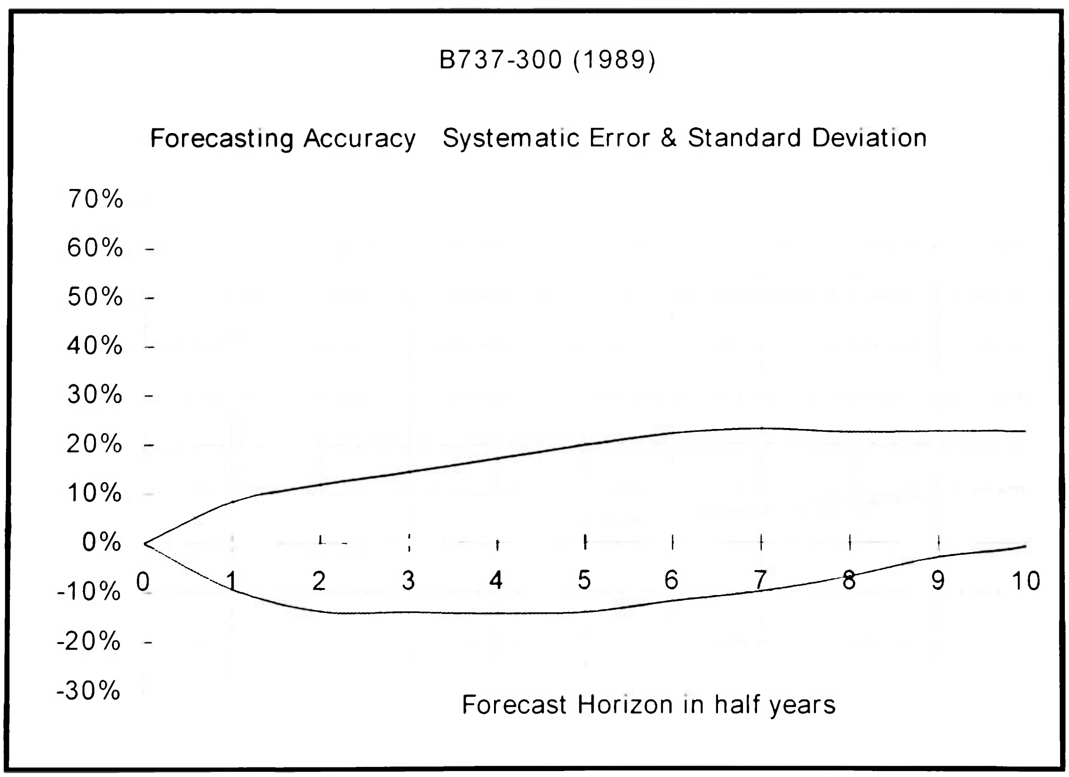
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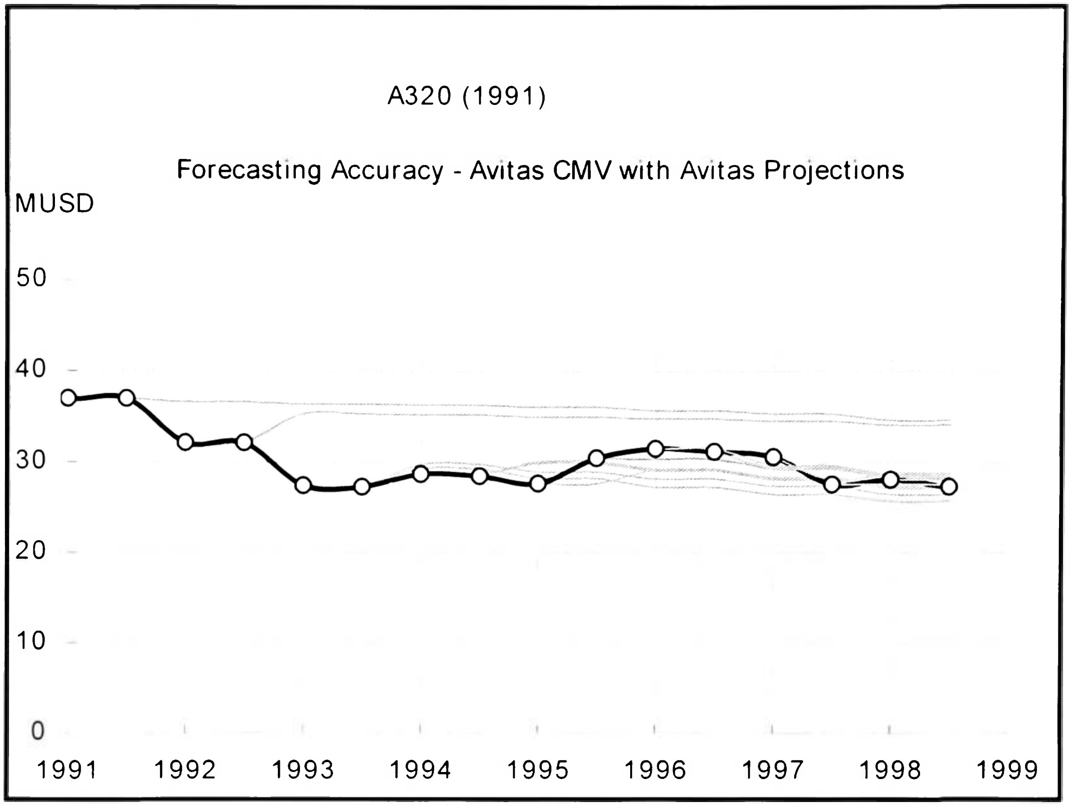
Forecast Horizon in half years



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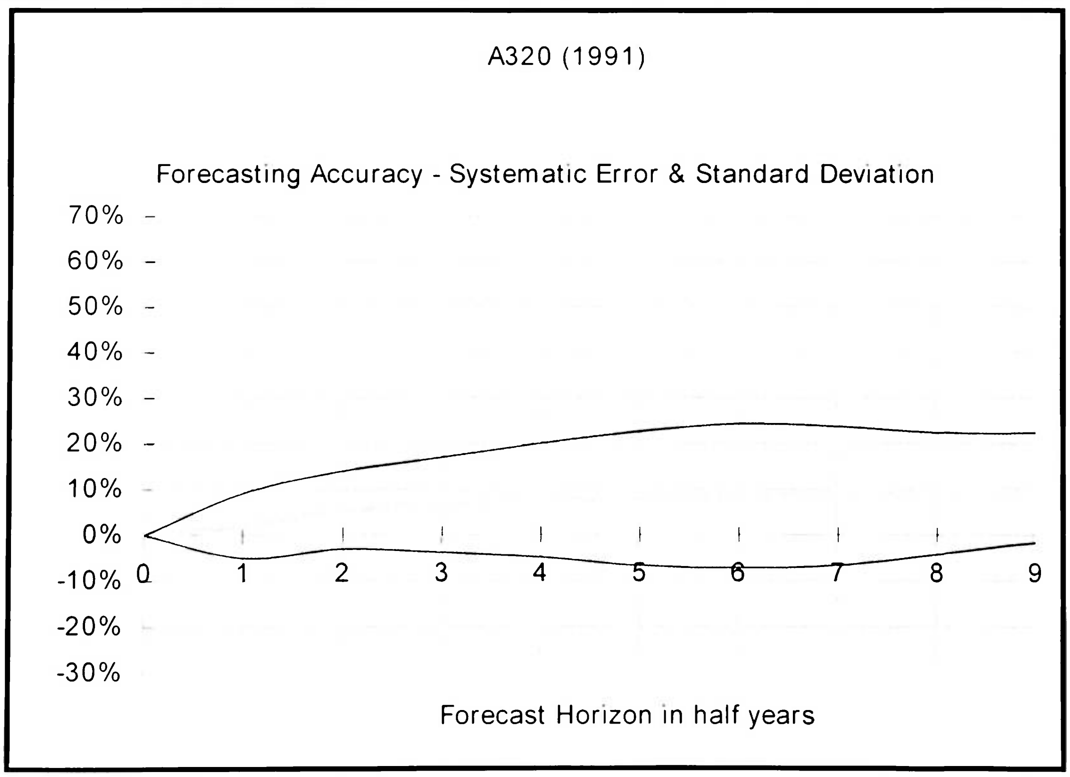

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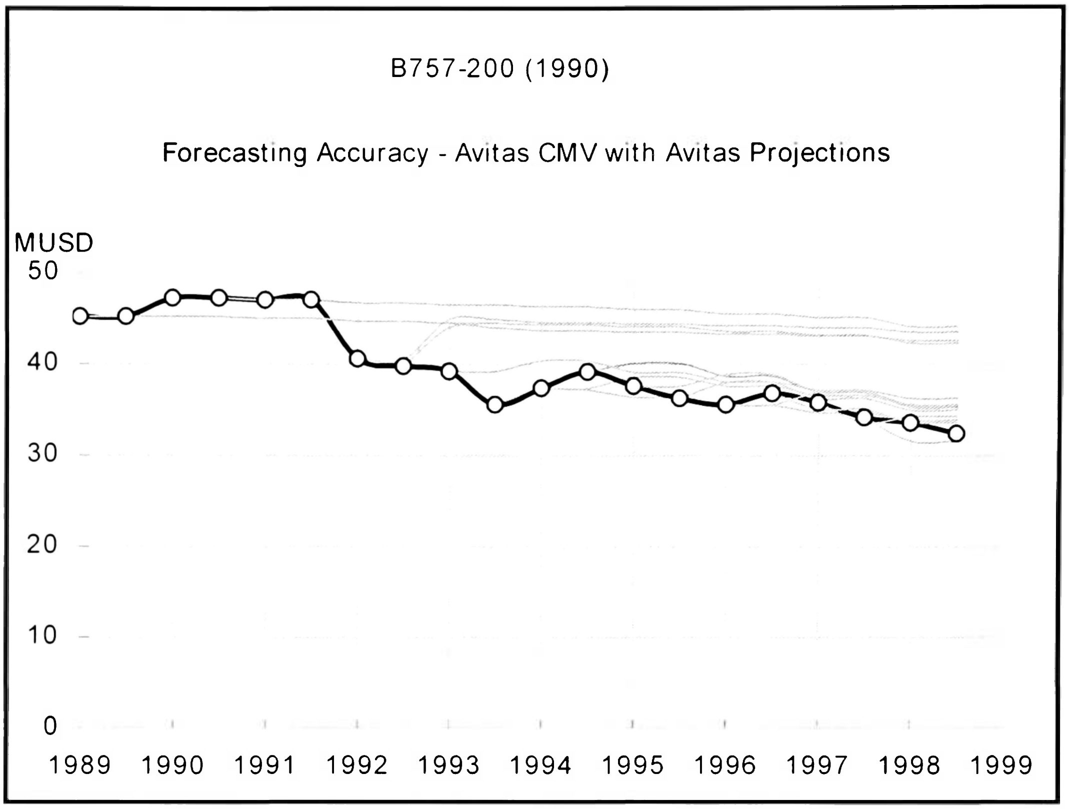
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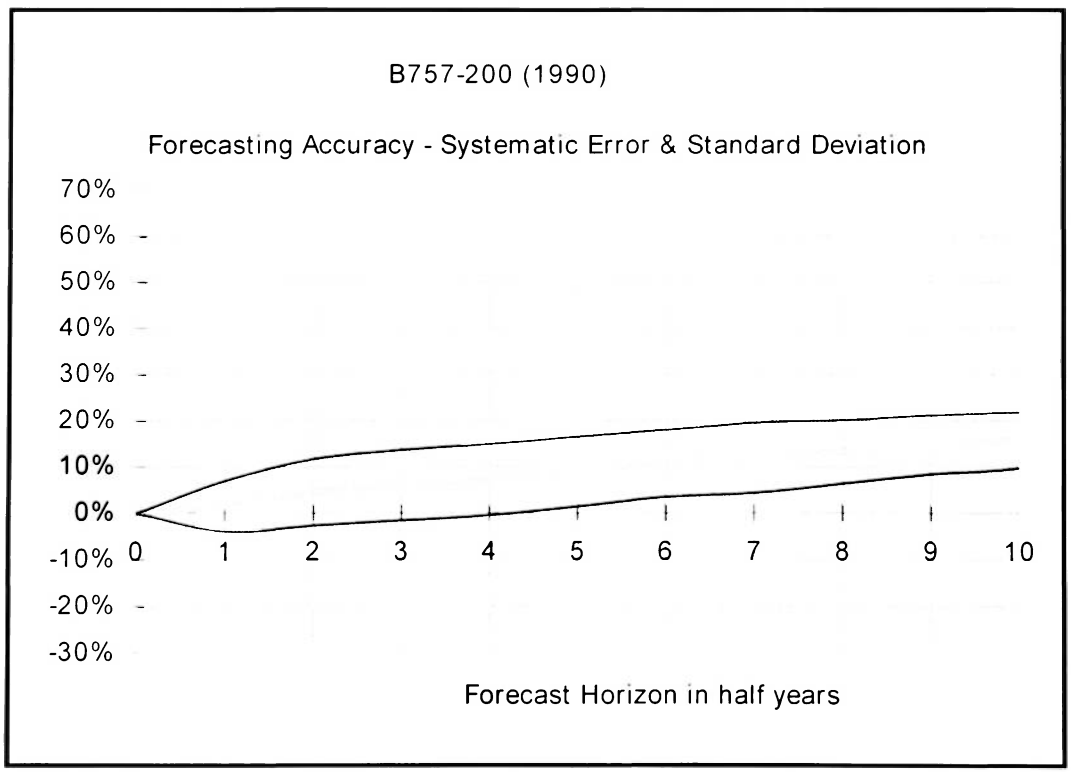
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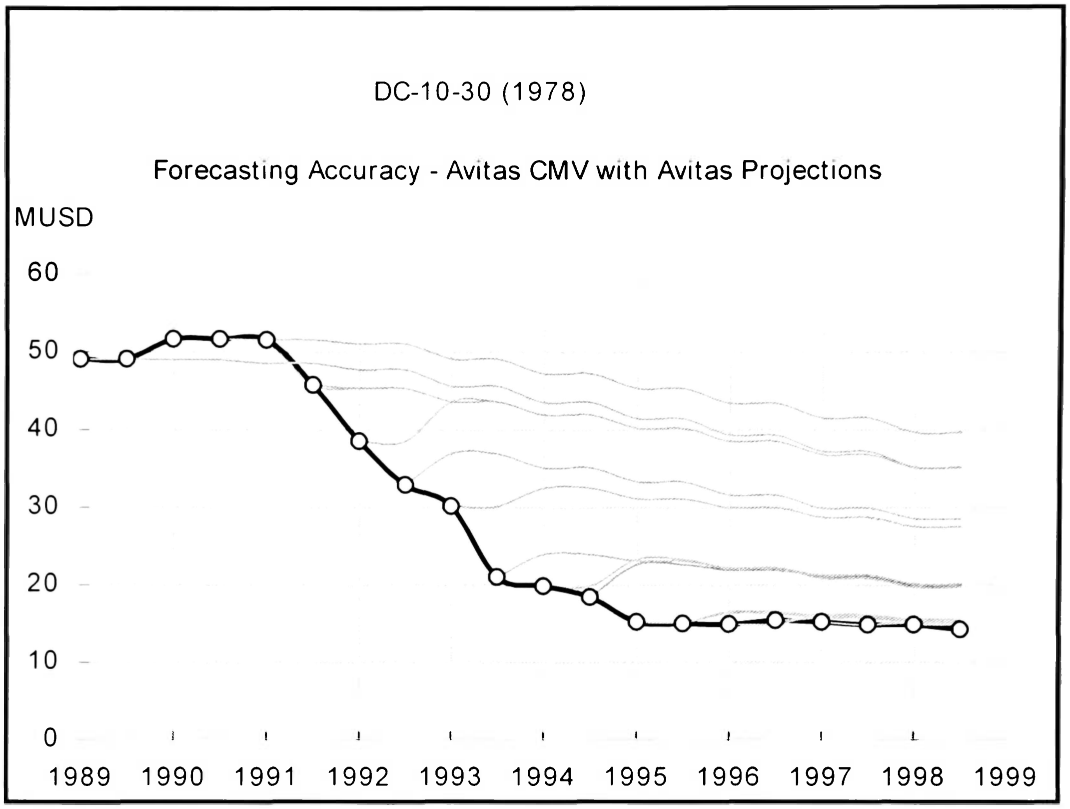
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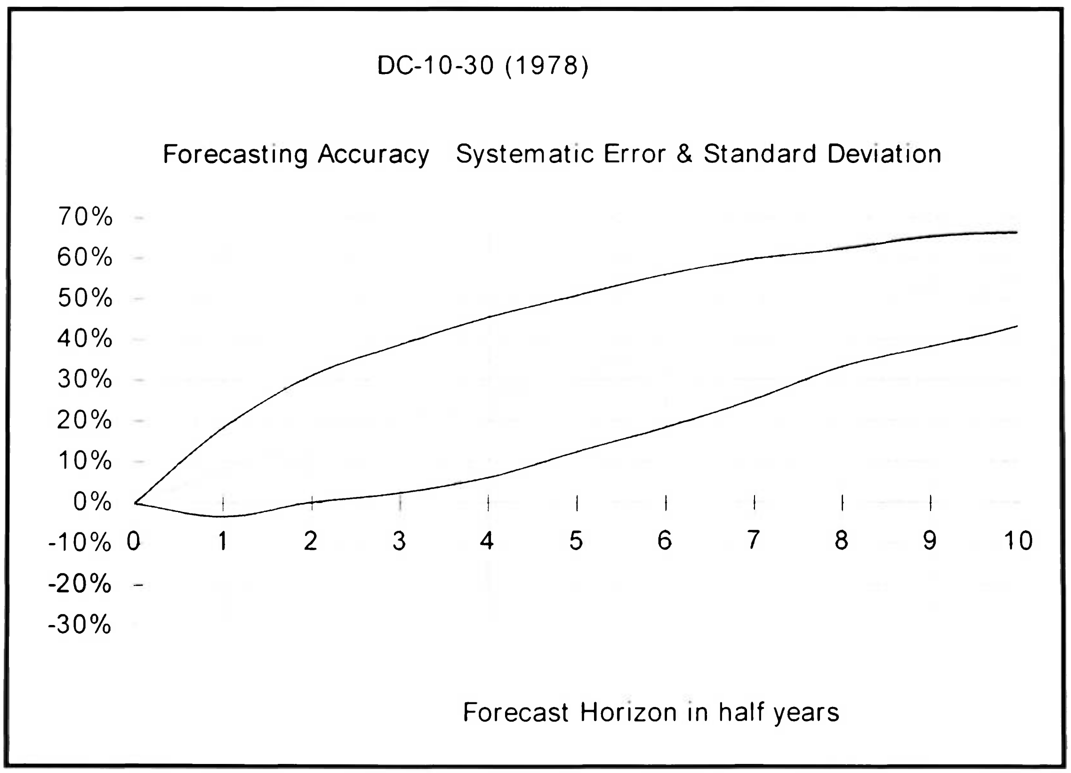
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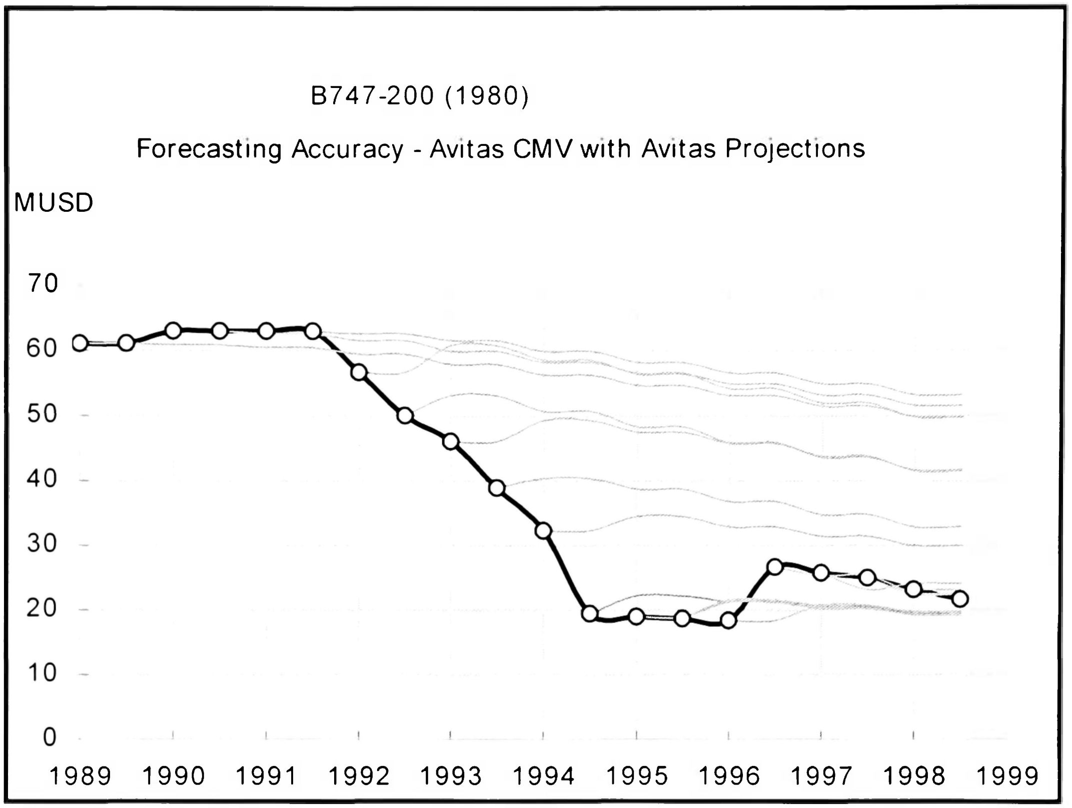
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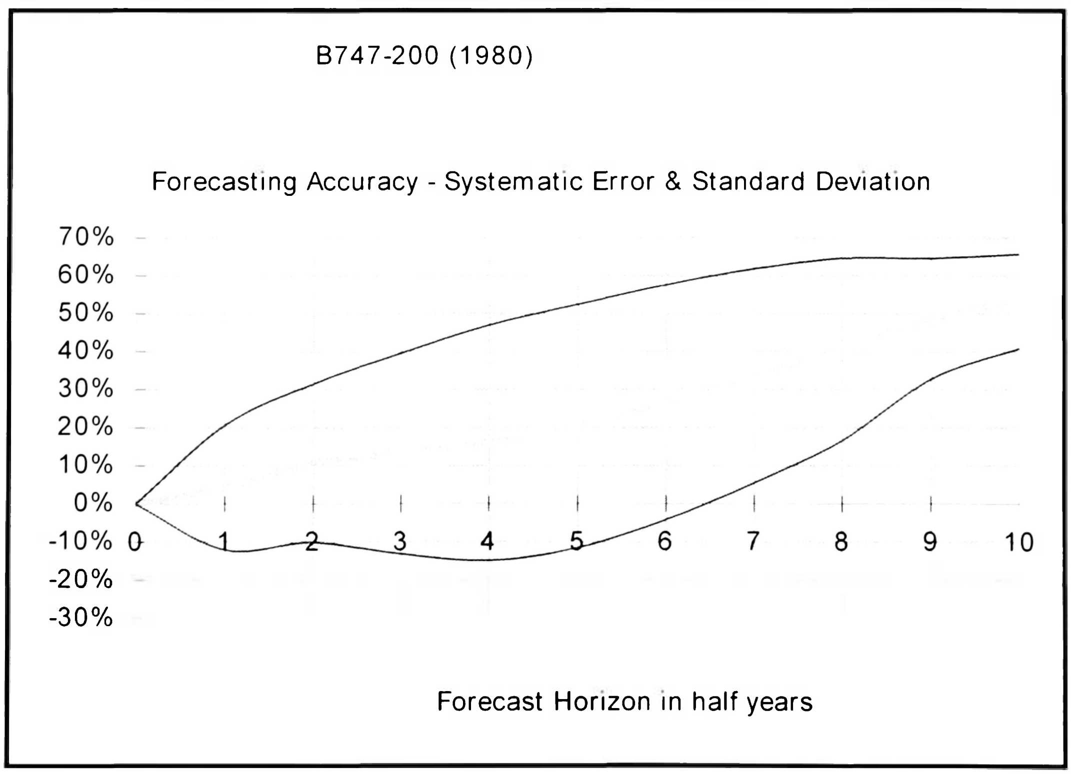
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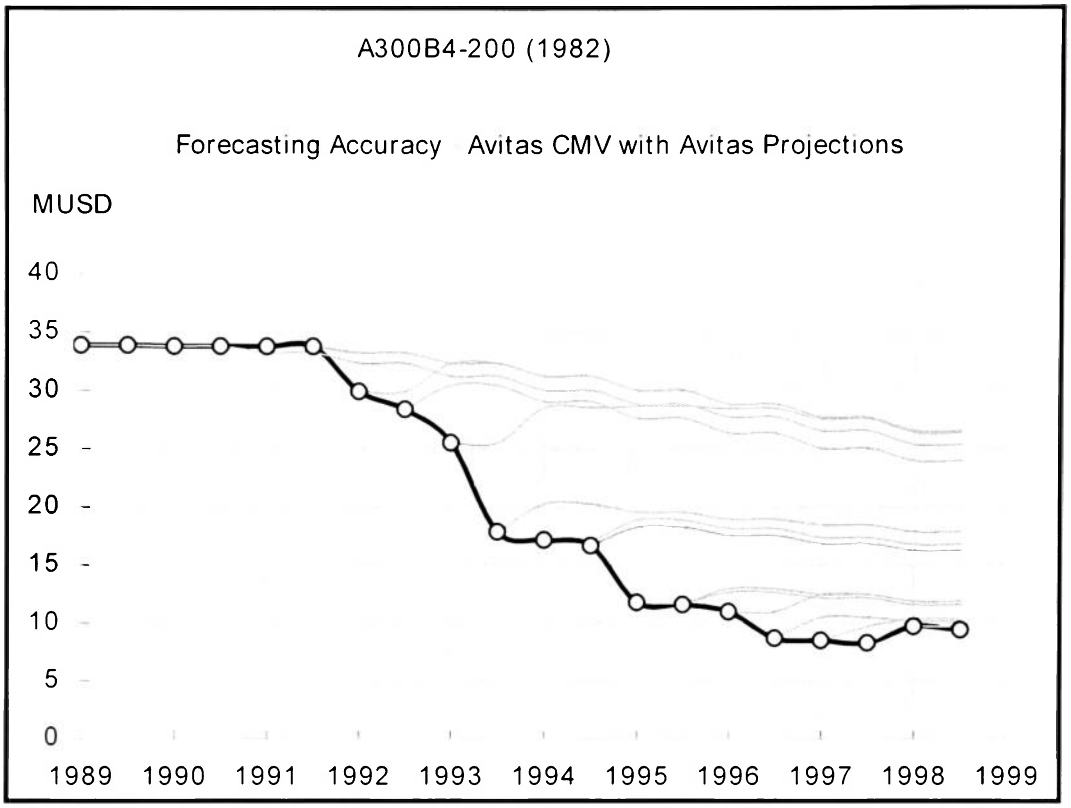
Forecast Horizon in half years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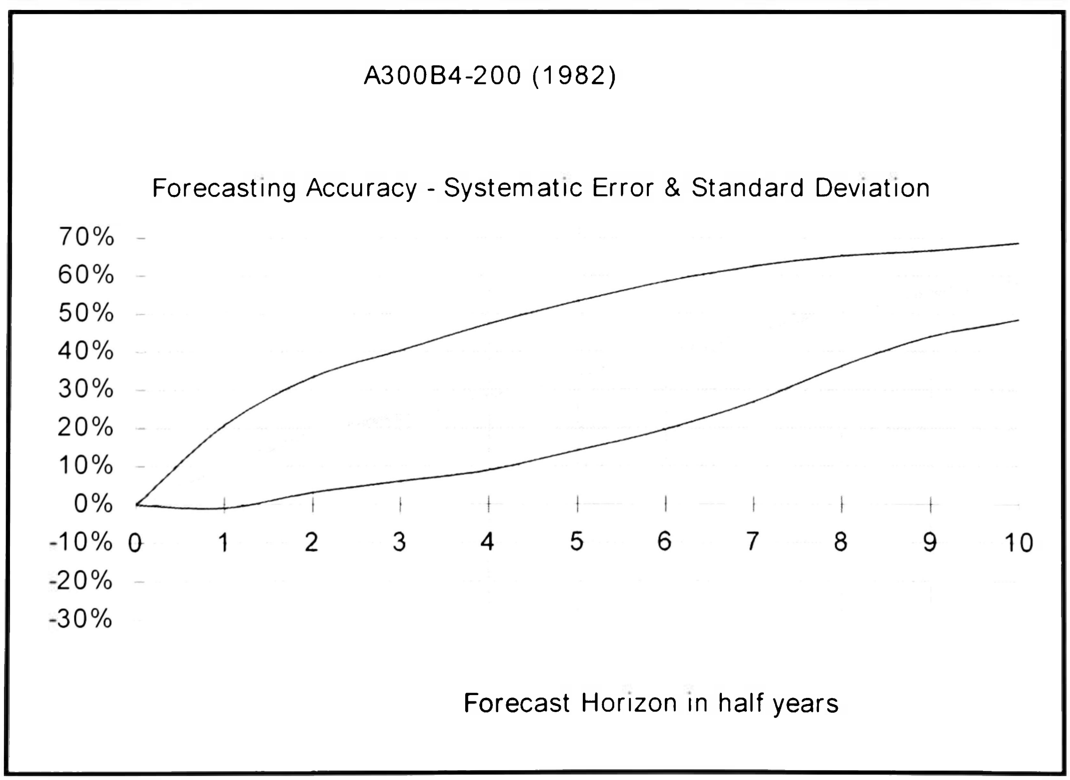
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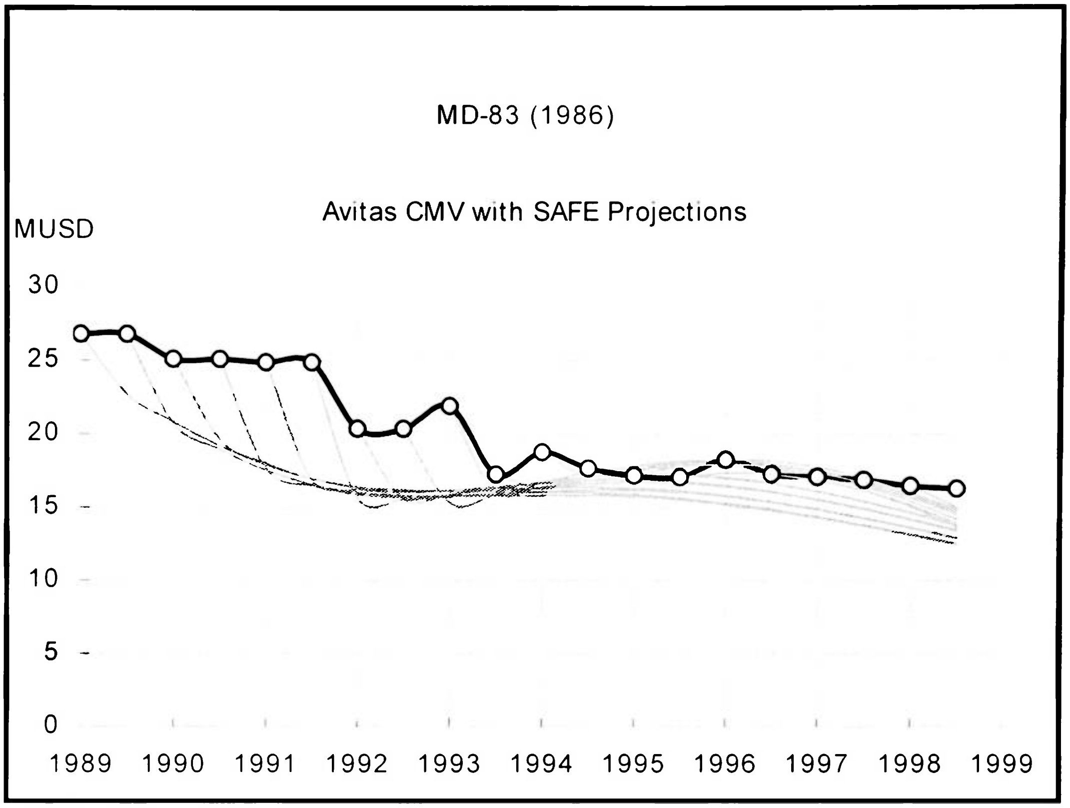
Forecast Horizon in half years


MD-83 (1986)
Avitas CMV with SAFE Projections
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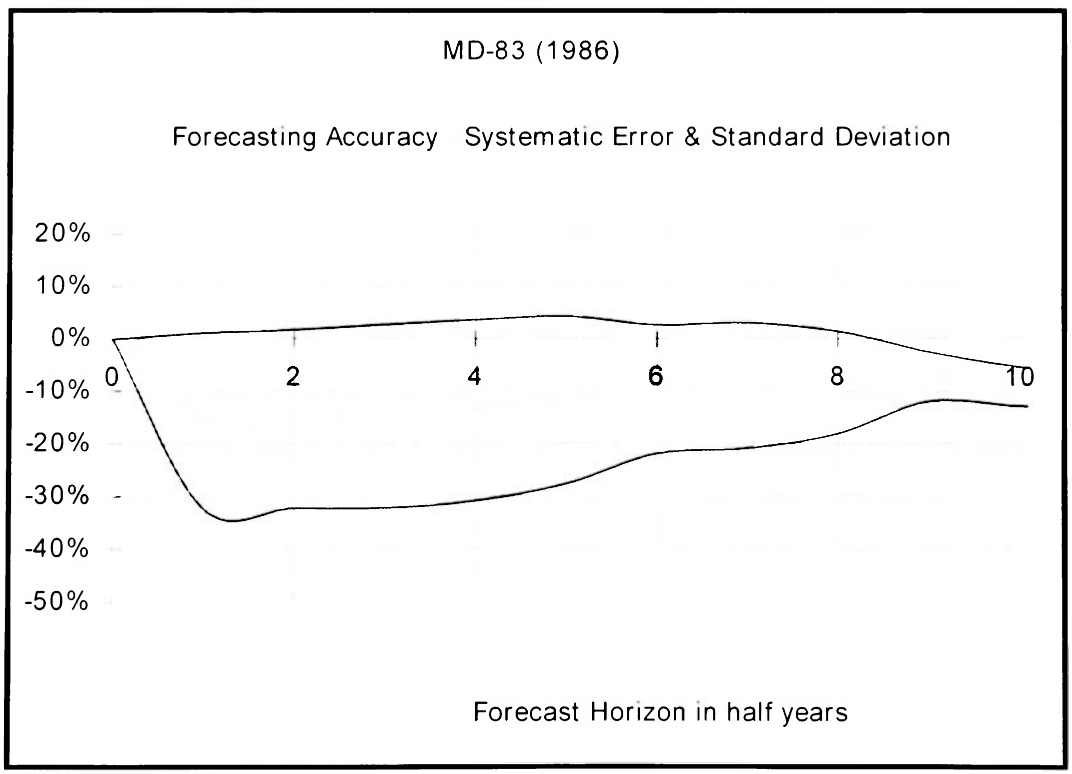
MD-83 (1986)
Forecasting Accuracy Systematic Error & Standard Deviation
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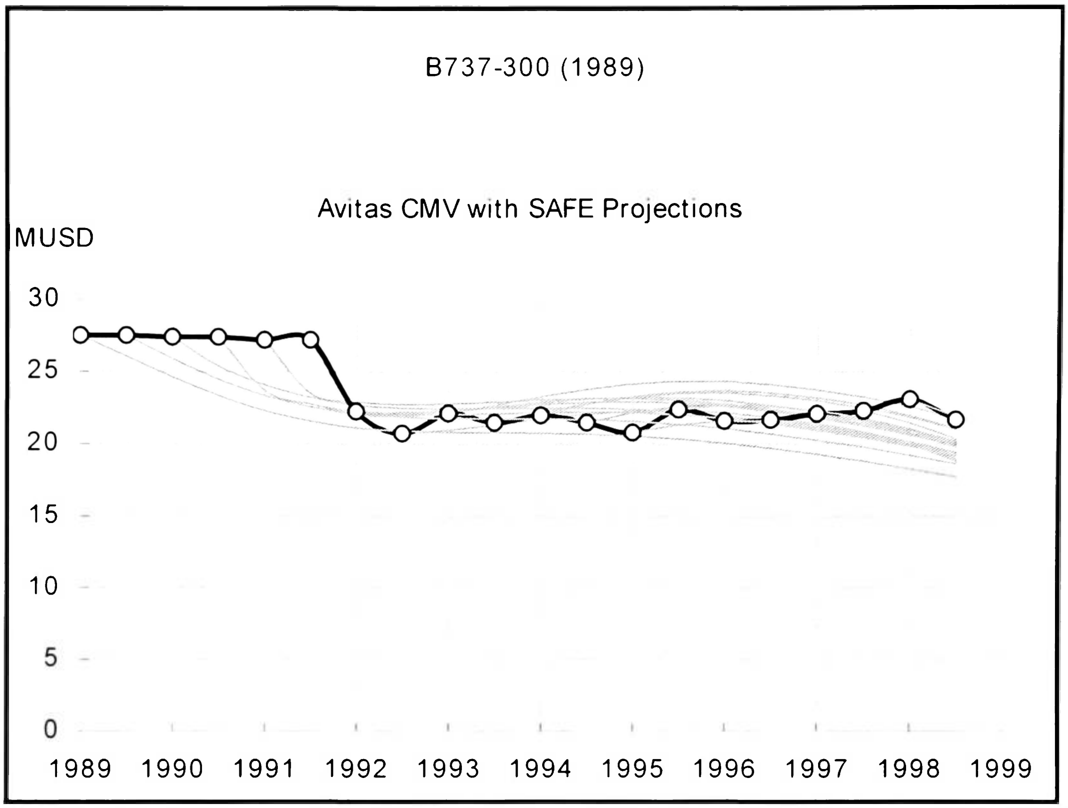
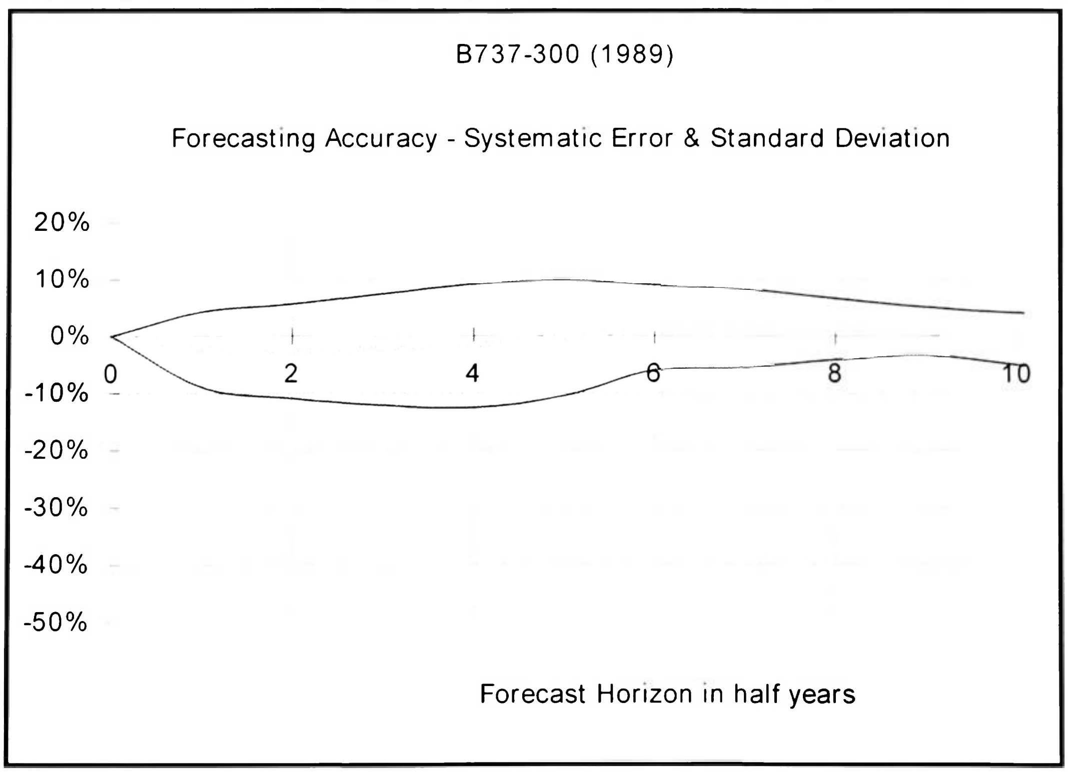
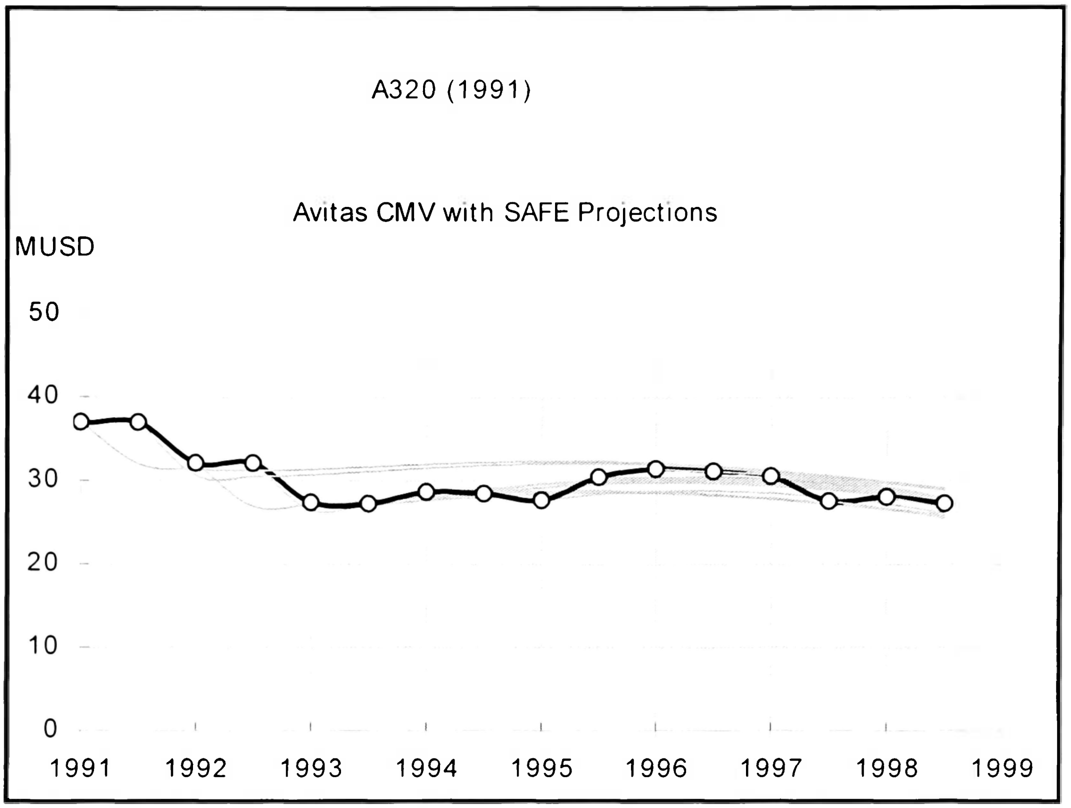
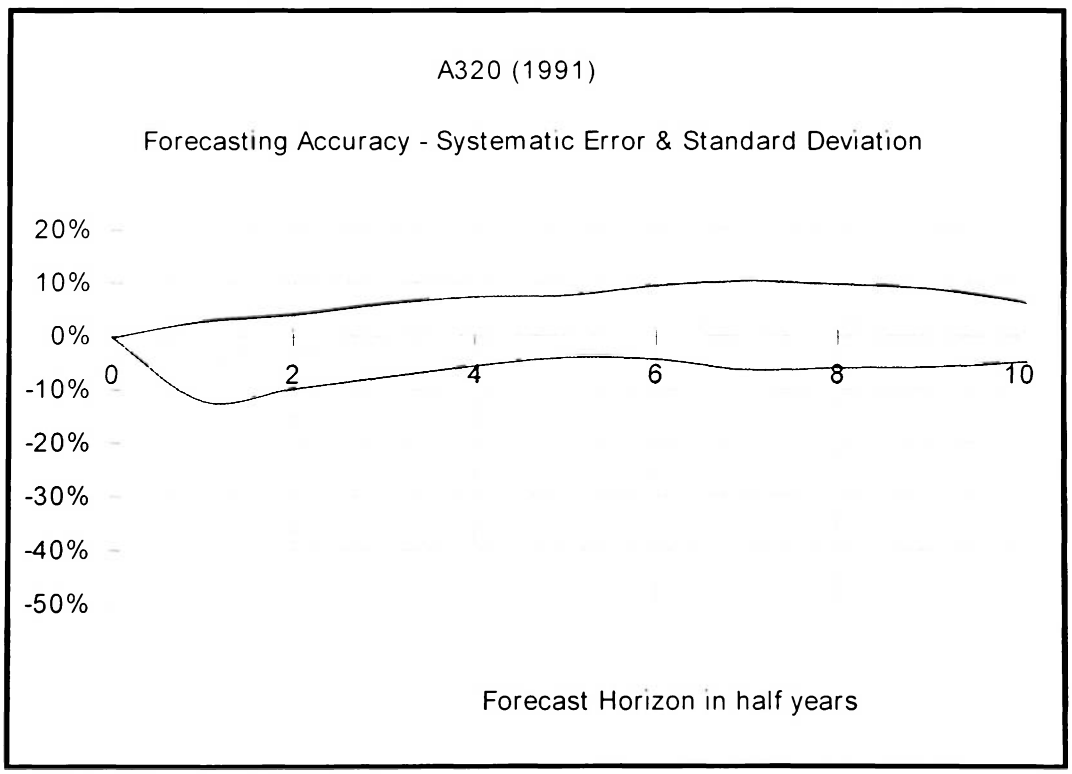
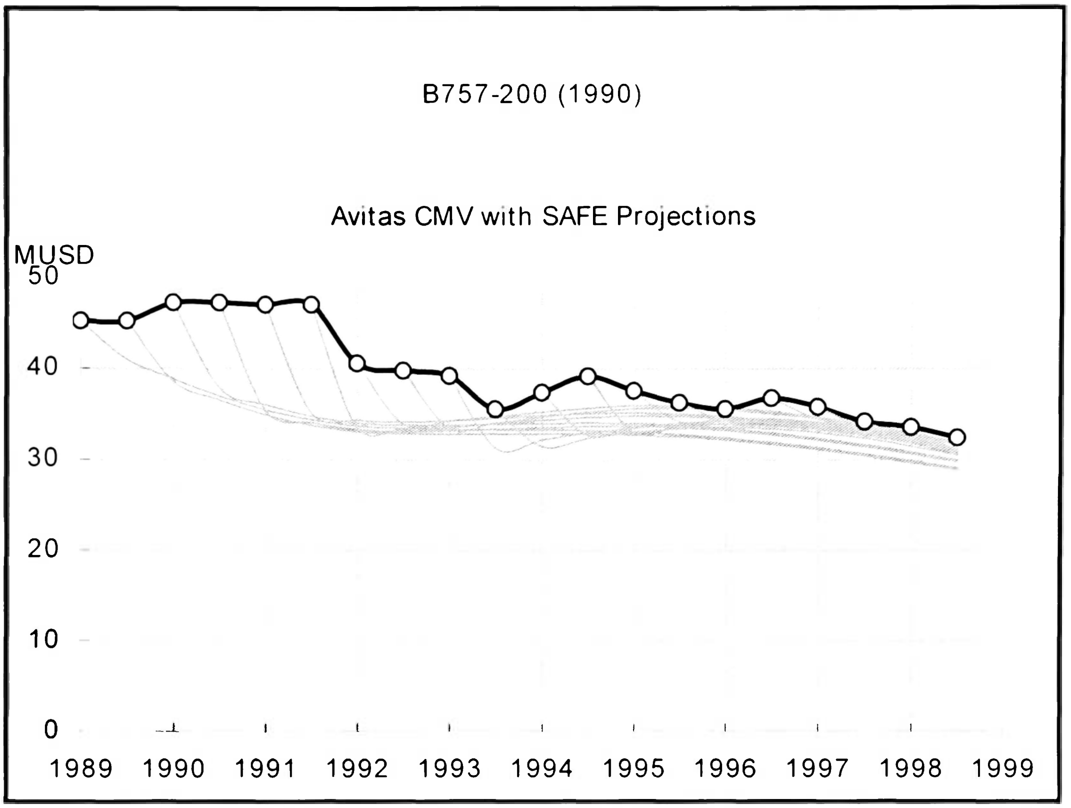
-20%
-30%
-40%
-50%
0
2
4
6
8
10
Forecast Horizon in half years

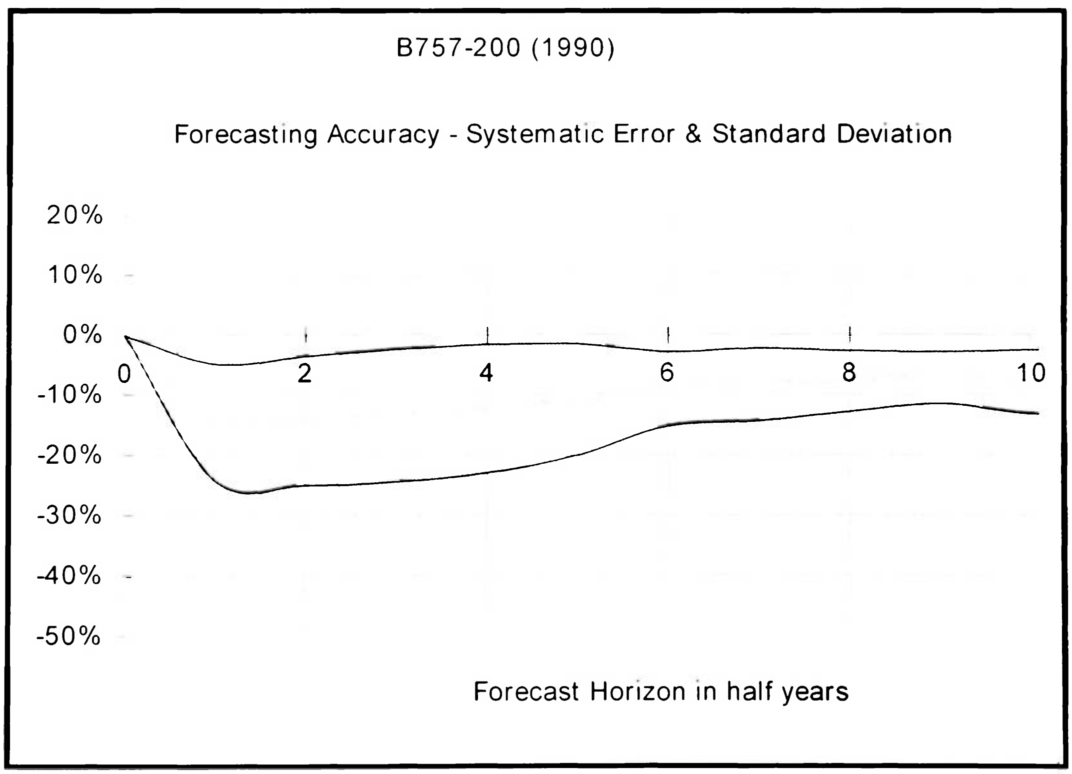

B737-300 (1989)
Avitas CMV with SAFE Projections
MUSD
30
25
20
15
10
5
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

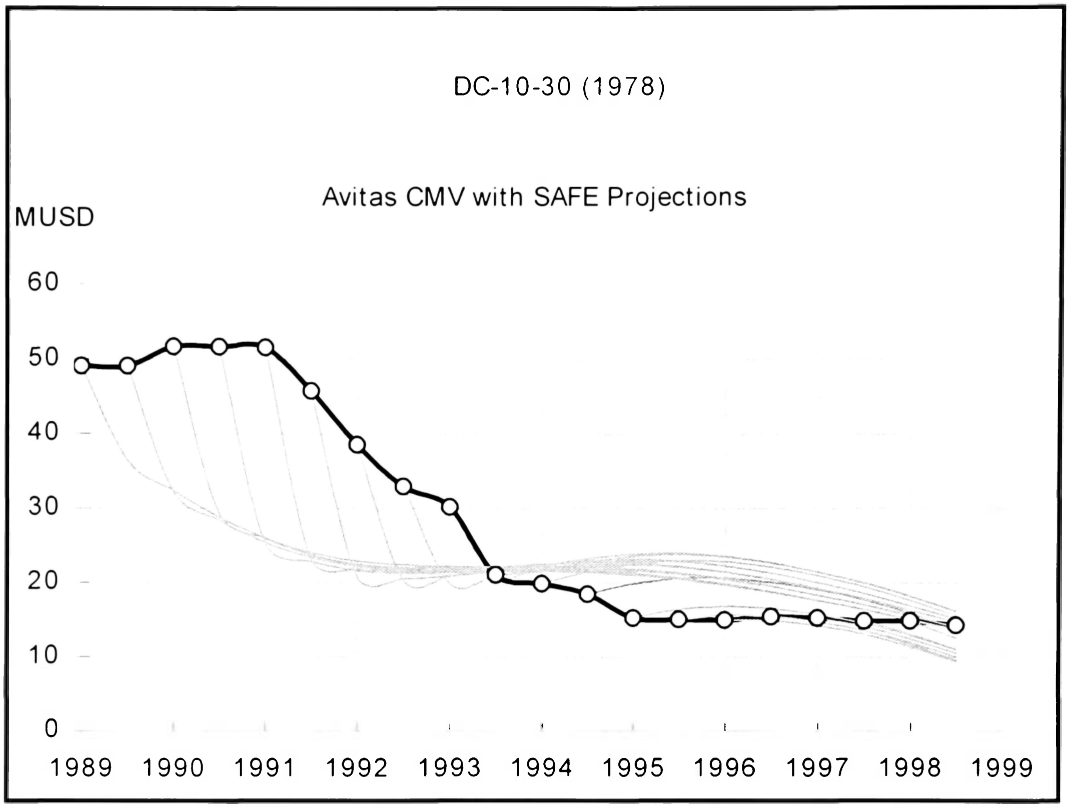

B737-300 (1989)
Forecasting Accuracy - Systematic Error & Standard Deviation
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
2
4
6
8
10
Forecast Horizon in half years


A320 (1991)
Avitas CMV with SAFE Projections
MUSD
50
40
30
20
10
0
1991
1992
1993
1994
1995
1996
1997
1998
1999


A320 (1991)
Forecasting Accuracy - Systematic Error & Standard Deviation
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
2
4
6
8
10
Forecast Horizon in half years


B757-200 (1990)
Avitas CMV with SAFE Projections
MUSD
50
40
30
20
10
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999


B757-200 (1990)
Forecasting Accuracy - Systematic Error & Standard Deviation
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
2
4
6
8
10
Forecast Horizon in half years


DC-10-30 (1978)
Avitas CMV with SAFE Projections
MUSD
60
50
40
30
20
10
0
1989
1990
1991
1992
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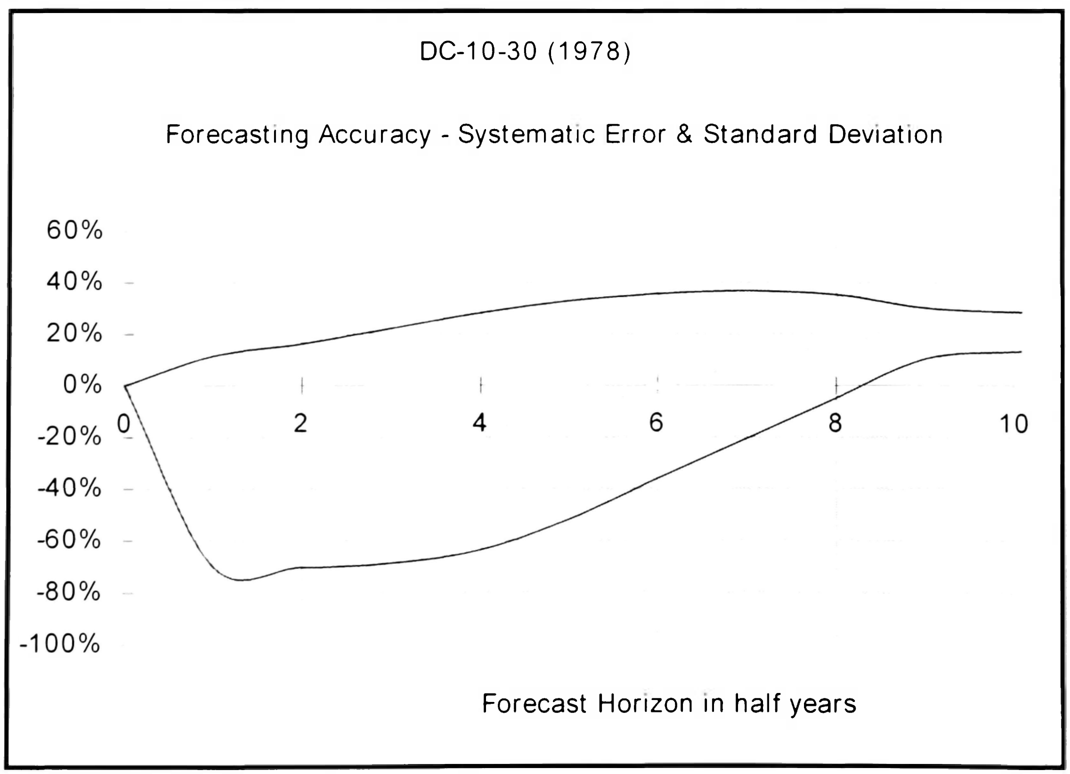
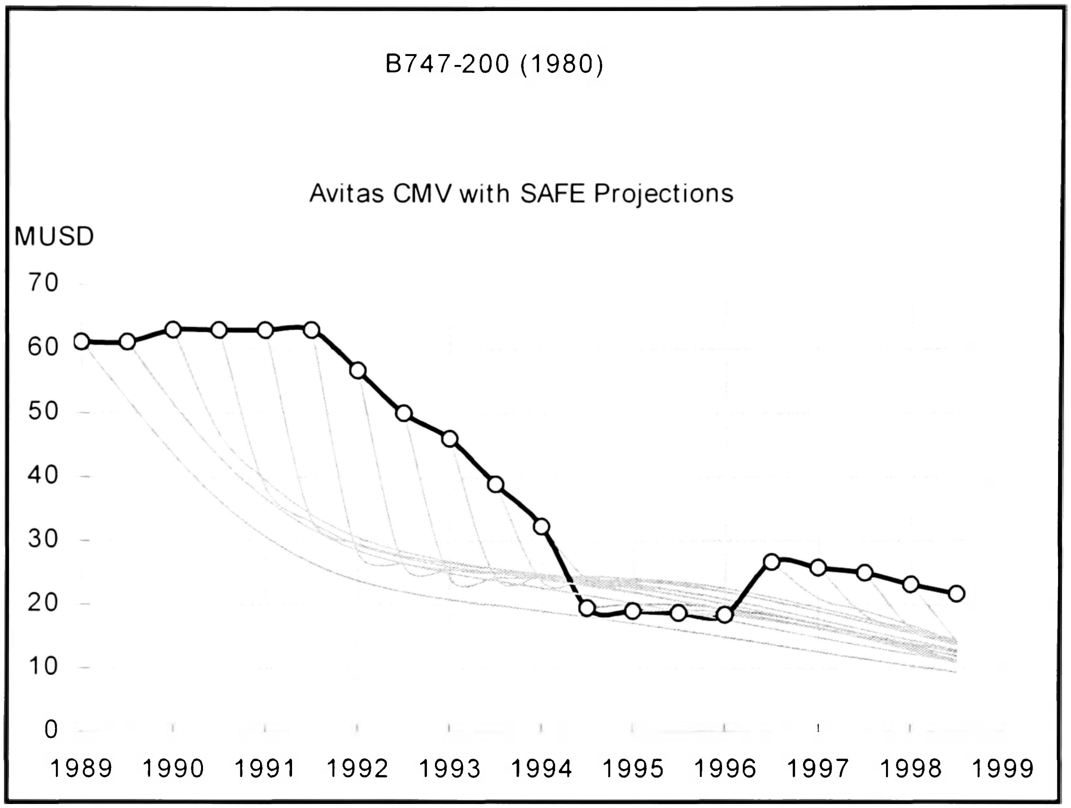
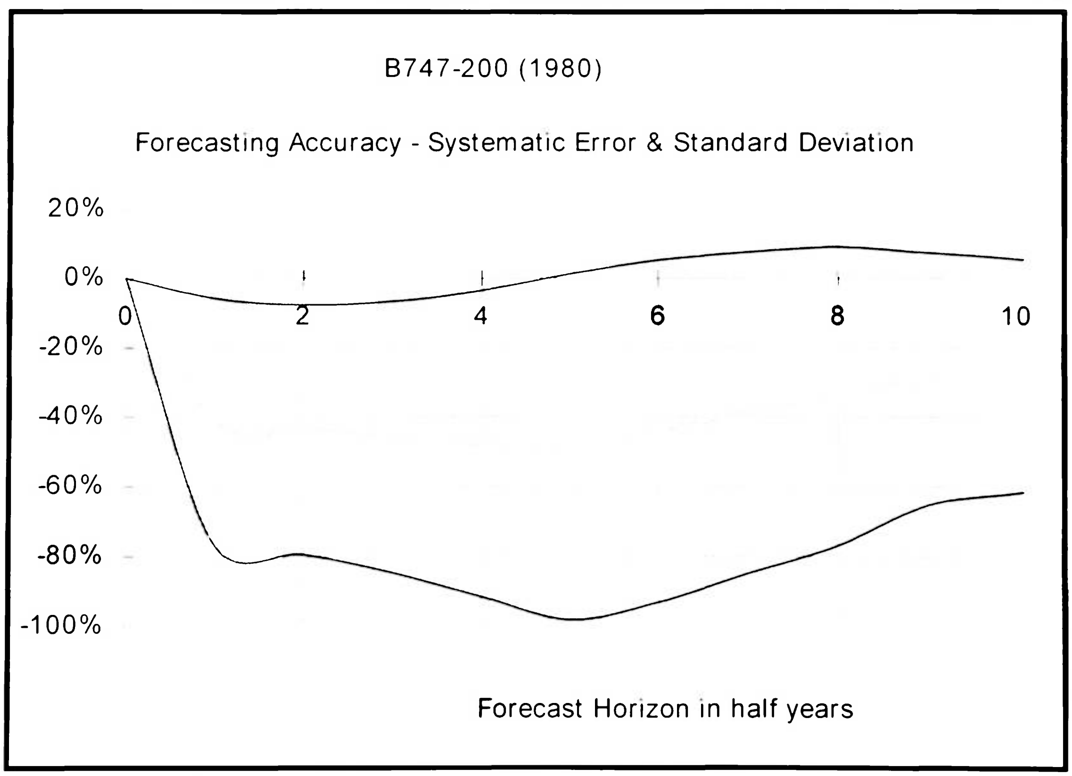
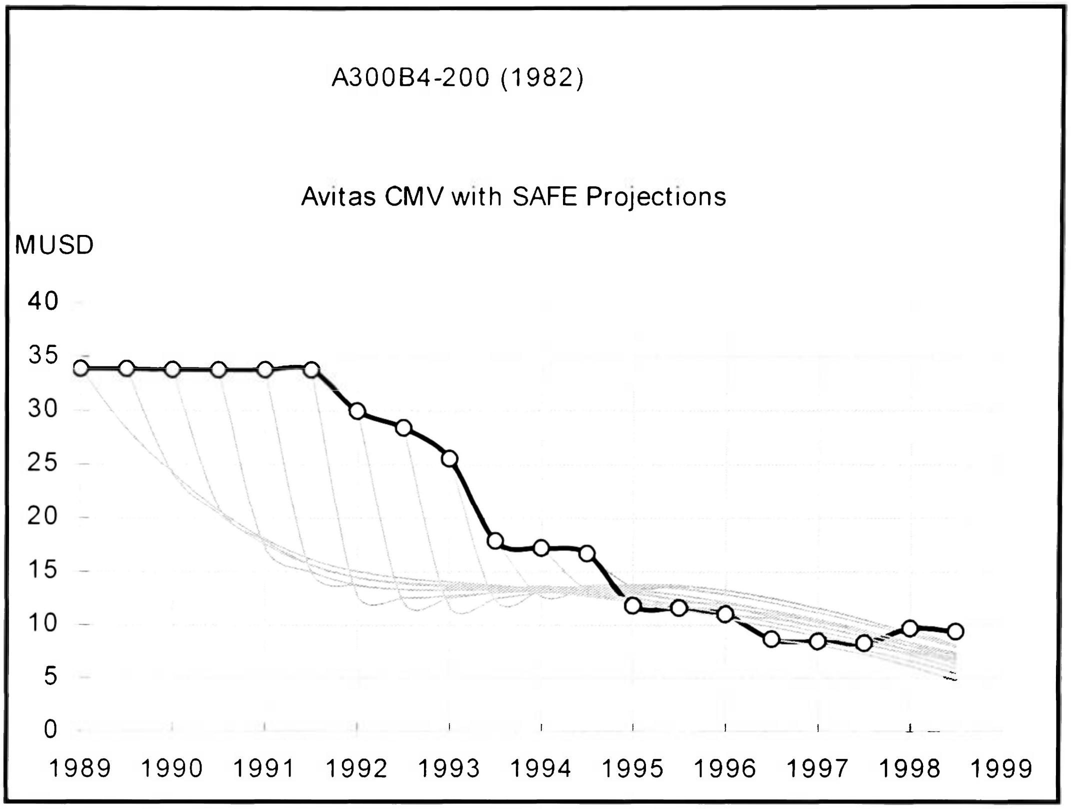
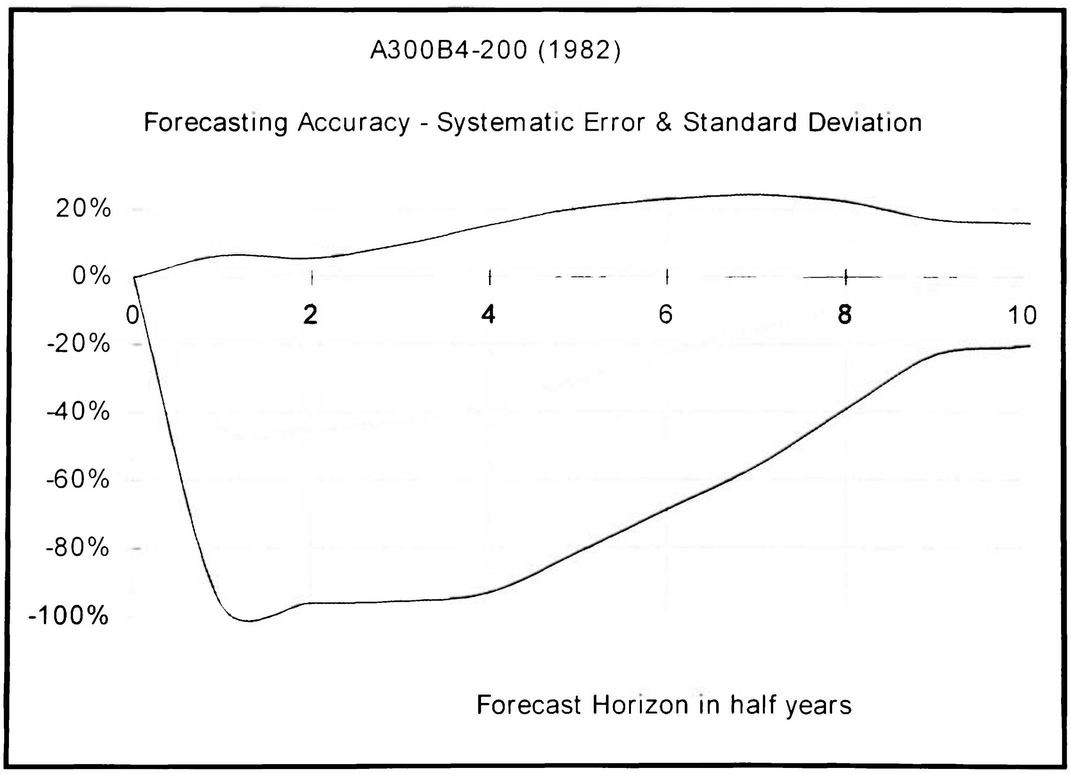
1994
1995
1996
1997
1998
1999


DC-10-30 (1978)
Forecasting Accuracy - Systematic Error & Standard Deviation
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
0
2
4
6
8
10
Forecast Horizon in half years


B747-200 (1980)
Avitas CMV with SAFE Projections
MUSD
70
60
50
40
30
20
10
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

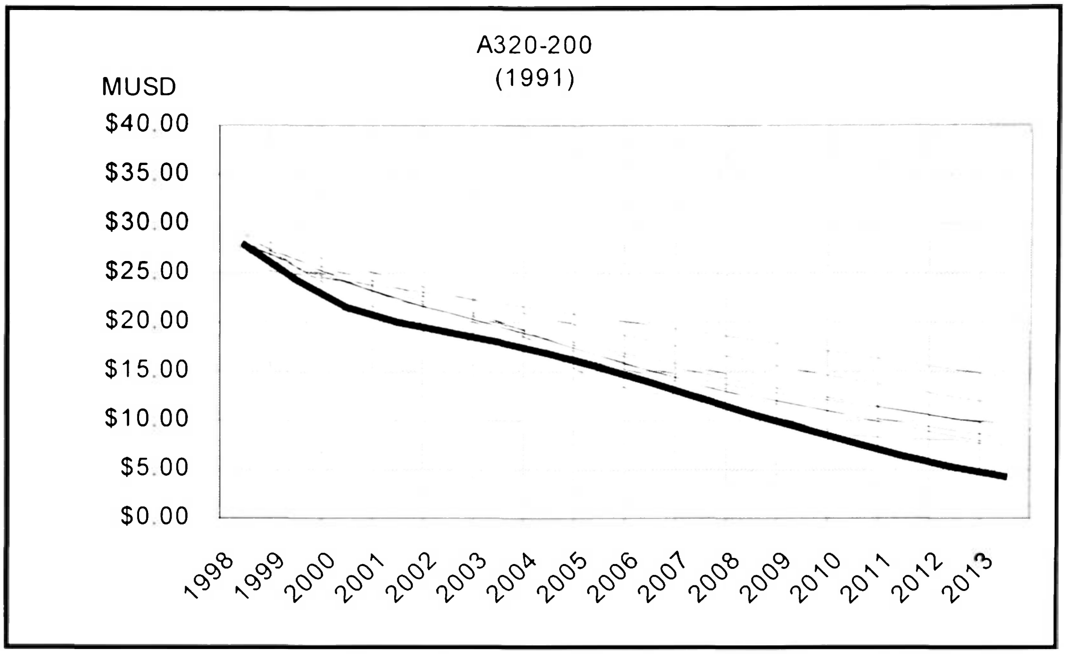

B747-200 (1980)
Forecasting Accuracy - Systematic Error & Standard Deviation
20%
0%
-20%
-40%
-60%
-80%
-100%
0
2
4
6
8
10
Forecast Horizon in half years

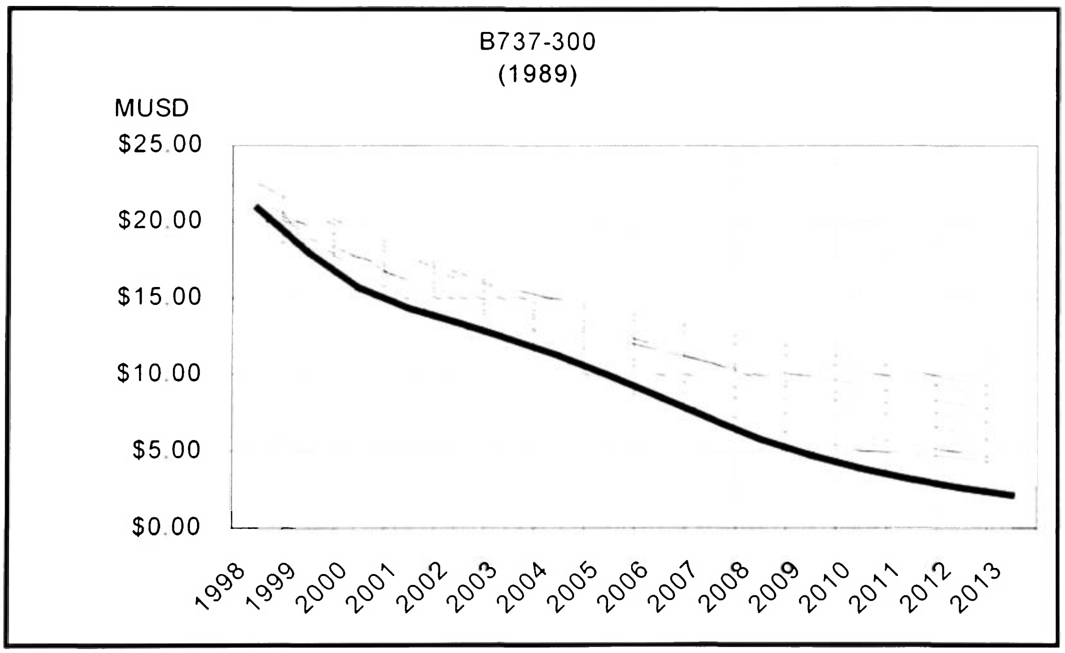

A300B4-200 (1982)
Avitas CMV with SAFE Projections
MUSD
40
35
30
25
20
15
10
5
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

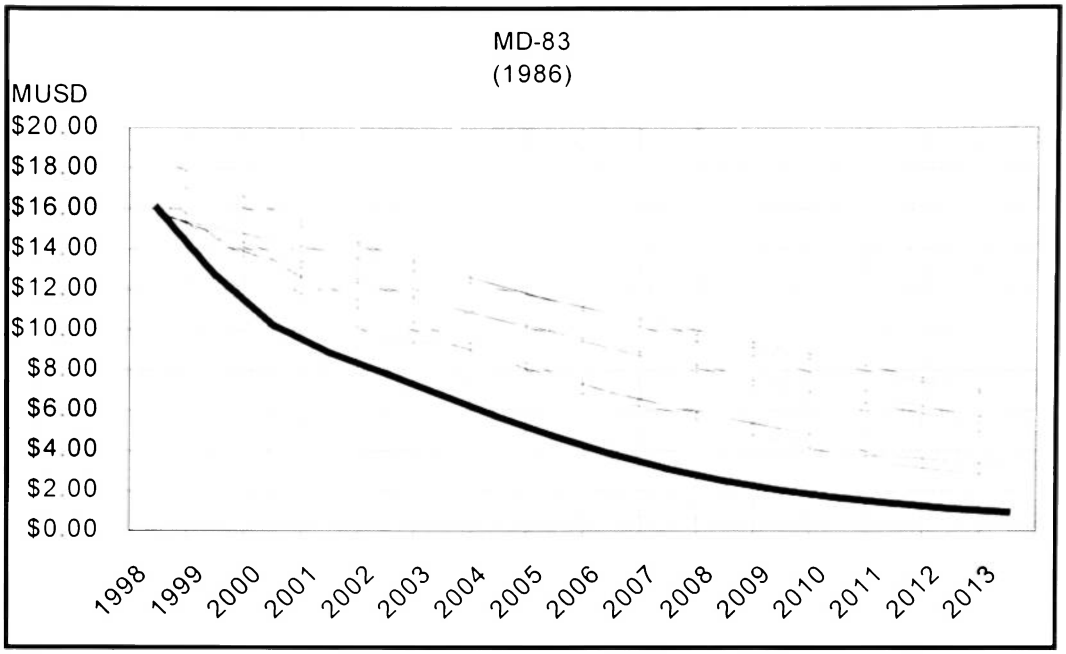

A300B4-200 (1982)
Forecasting Accuracy - Systematic Error & Standard Deviation
20%
0%
-20%
-40%
-60%
-80%
-100%
0
2
4
6
8
10
Forecast Horizon in half years

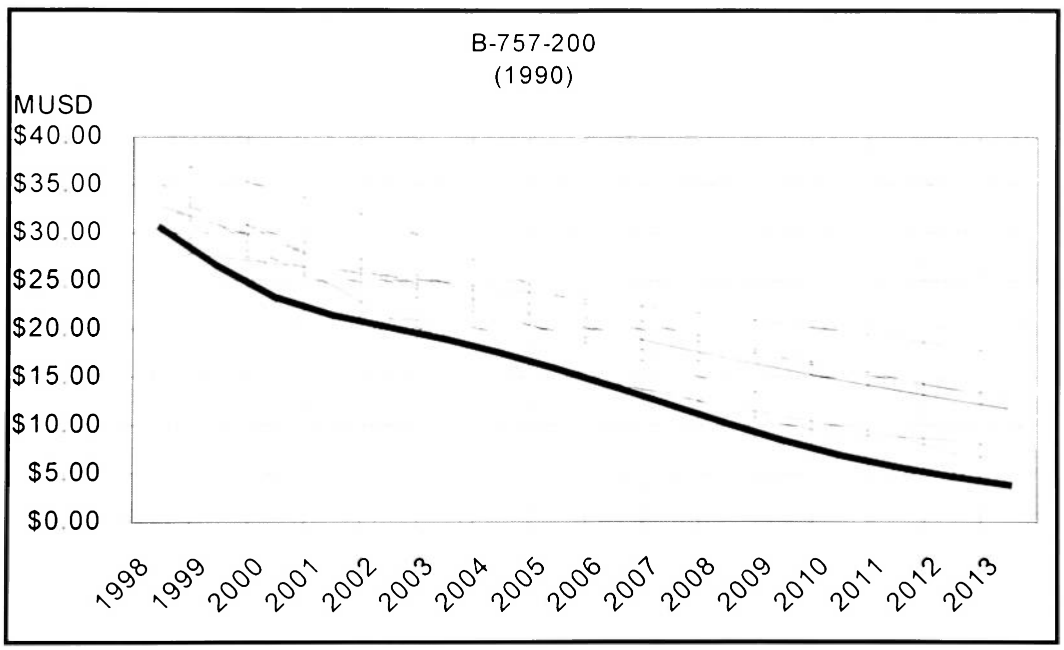
Appendix B

Appraiser Survey


A320-200
(1991)
MUSD
$40.00
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


B737-300
(1989)
MUSD
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


MD-83
(1986)
MUSD
$20.00
$18.00
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


B-757-200
(1990)
MUSD
$40.00
$35.00
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
1998
1999
2000
2001
2002
2003
2004
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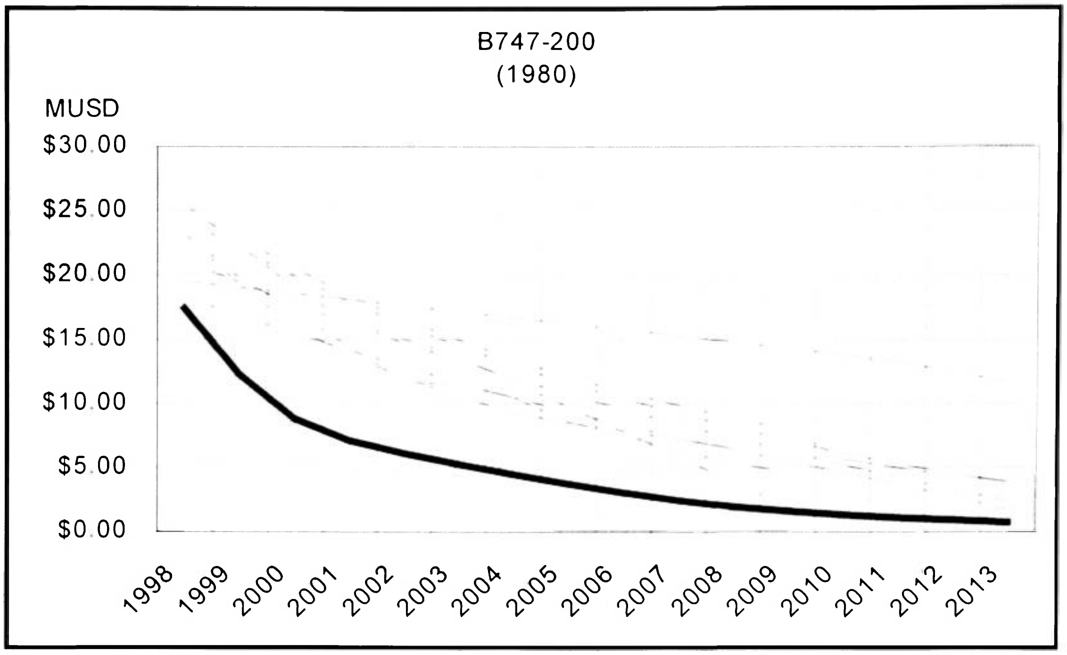
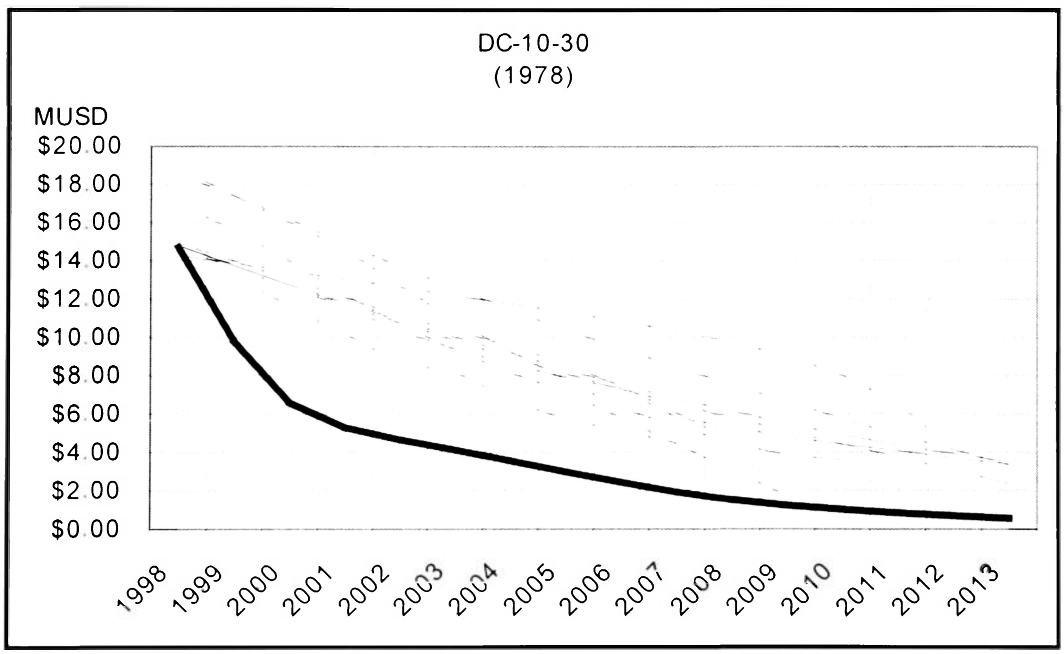
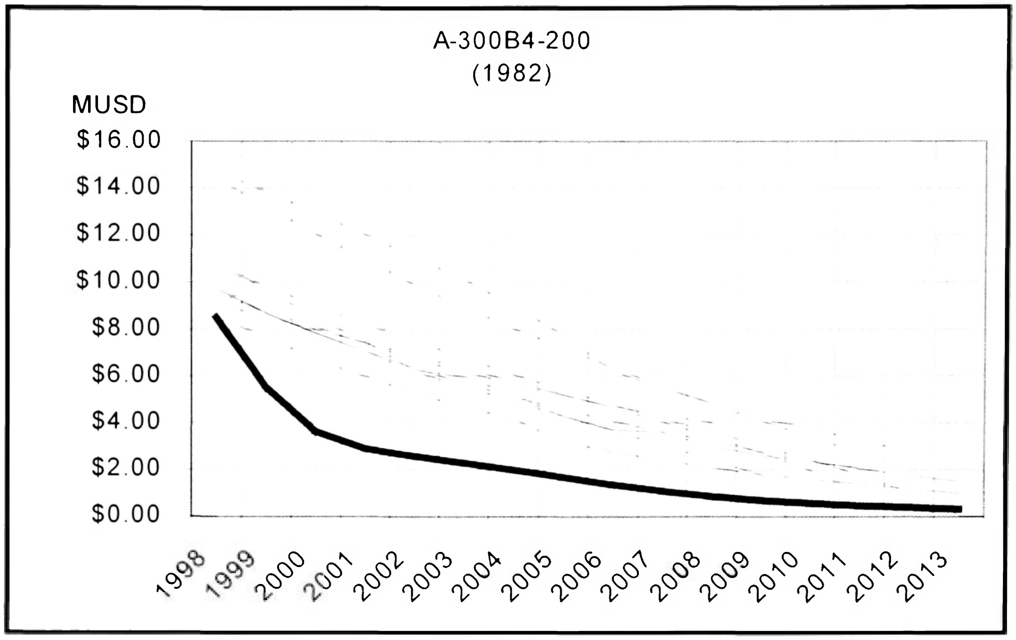
2006
2007
2008
2009
2010
2011
2012
2013


B747-200
(1980)
MUSD
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


DC-10-30
(1978)
MUSD
$20.00
$18.00
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


A-300B4-200
(1982)
MUSD
$16.00
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

Appendix C

Model

			DISCOUNT RATE =		12%
				NPV =	$26,449,994
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
	$	$	$		
1985	0 085	0 098	0 083	156,876,000	$ 2,413,022
1986	0 083	0 096	0 081	176,289,474	$ 2,583,484
1987	0 088	0 101	0 084	169,157,801	$ 2,872,681
1988	0 094	0 108	0 089	171,900,596	$ 3,301,566
1989	0 101	0 116	0 099	173,572,843	$ 3,096,382
1990	0 104	0 119	0 106	172,725,318	$ 2,239,549
1991	0 105	0 121	0 108	168,669,521	$ 2,237,853
1992	0 104	0 119	0 107	173,827,400	$ 2,142,112
1993	0 110	0 126	0 108	172,393,908	$ 3,155,039
1994	0 113	0 129	0 109	171,956,533	$ 3,499,169
1995	0 117	0 135	0 110	171,160,637	$ 4,251,281
1996	0 122	0 140	0 115	177,774,340	$ 4,581,802
1997	0 127	0 146	0 117	182,139,830	$ 5,300,024
1998	0 124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573

			DISCOUNT RATE =		12%
				NPV =	**$25,165,345**
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
	$	$	$		
1985	0 087	0 099	0 086	162,536,374	$ 2,173,924
1986	0 089	0 103	0 089	164,451,708	$ 2,303,968
1987	0 092	0 106	0 092	166,251,564	$ 2,434,754
1988	0 095	0 109	0 094	167,935,941	$ 2,566,061
1989	0 098	0 113	0 097	169,504,840	$ 2,697,670
1990	0 101	0 116	0 100	170,958,260	$ 2,829,359
1991	0 104	0 119	0 102	172,296,201	$ 2,960,910
1992	0 107	0 123	0 105	173,518,664	$ 3,092,103
1993	0 110	0 126	0 108	174,625,649	$ 3,222,716
1994	0 113	0 129	0 110	175,617,155	$ 3,352,531
1995	0 116	0 133	0 113	176,493,182	$ 3,481,328
1996	0 118	0 136	0 116	177,253,731	$ 3,608,886
1997	0 121	0 139	0 119	177,898,801	$ 3,734,985
1998	0 124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573

			DISCOUNT RATE =		12%
				NPV =	**$33,953,815**
	Revenue/ ASM	Revenue + 20%	Expenses/ ASM	ASM	CF
1985	0 085	0 102	0 083	156,876,000	$ 3,081,211
1986	0 083	0 100	0 081	176,289,474	$ 3,316,649
1987	0 088	0 105	0 084	169,157,801	$ 3,615,649
1988	0 094	0 113	0 089	171,900,596	$ 4,111,143
1989	0 101	0 122	0 099	173,572,843	$ 3,975,384
1990	0 104	0 125	0 106	172,725,318	$ 3,136,198
1991	0 105	0 126	0 108	168,669,521	$ 3,124,106
1992	0 104	0 125	0 107	173,827,400	$ 3,044,305
1993	0 110	0 132	0 108	172,393,908	$ 4,099,616
1994	0 113	0 135	0 109	171,956,533	$ 4,467,260
1995	0 117	0 141	0 110	171,160,637	$ 5,254,156
1996	0 122	0 147	0 115	177,774,340	$ 5,667,148
1997	0 127	0 153	0 117	182,139,830	$ 6,459,188
1998	0 124	0 149	0 121	178,428,393	$ 4,967,446
1999	0 127	0 153	0 124	178,842,506	$ 5,118,473
2000	0 130	0 156	0 127	179,141,141	$ 5,266,750
2001	0 133	0 159	0 129	179,324,297	$ 5,412,007
2002	0 136	0 163	0 132	179,391,974	$ 5,553,976
2003	0 139	0 166	0 135	179,344,173	$ 5,692,384
2004	0 142	0 170	0 137	179,180,893	$ 5,826,963
2005	0 145	0 173	0 140	178,902,135	$ 5,957,441
2006	0 147	0 177	0 143	178,507,899	$ 6,083,549
2007	0 150	0 180	0 146	177,998,183	$ 6,205,017
2008	0 153	0 184	0 148	177,372,989	$ 6,321,573
2009	0 156	0 187	0 151	176,632,317	$ 6,432,949
2010	0 159	0 191	0 154	175,776,166	$ 6,538,873
2011	0 162	0 194	0 156	174,804,537	$ 6,639,076
2012	0 165	0 198	0 159	173,717,429	$ 6,733,288
2013	0 168	0 201	0 162	172,514,842	$ 6,821,237
2014	0 171	0 205	0 164	171,196,777	$ 6,902,654
2015	0 174	0 208	0 167	169,763,233	$ 6,977,269

			DISCOUNT RATE =		12%
				NPV =	**$18,946,173**
	Revenue/ ASM	Revenue + 10%	Expenses/ ASM	ASM	CF
1985	0 085	0 094	0 083	156,876,000	$ 1,744,833
1986	0 083	0 091	0 081	176,289,474	$ 1,850,319
1987	0 088	0 097	0 084	169,157,801	$ 2,129,713
1988	0 094	0 104	0 089	171,900,596	$ 2,491,989
1989	0 101	0 111	0 099	173,572,843	$ 2,217,381
1990	0 104	0 114	0 106	172,725,318	$ 1,342,899
1991	0 105	0 116	0 108	168,669,521	$ 1,351,600
1992	0 104	0 114	0 107	173,827,400	$ 1,239,920
1993	0 110	0 121	0 108	172,393,908	$ 2,210,461
1994	0 113	0 124	0 109	171,956,533	$ 2,531,079
1995	0 117	0 129	0 110	171,160,637	$ 3,248,405
1996	0 122	0 134	0 115	177,774,340	$ 3,496,456
1997	0 127	0 140	0 117	182,139,830	$ 4,140,861
1998	0 124	0 137	0 121	178,428,393	$ 2,751,366
1999	0 127	0 140	0 124	178,842,506	$ 2,845,384
2000	0 130	0 143	0 127	179,141,141	$ 2,937,915
2001	0 133	0 146	0 129	179,324,297	$ 3,028,787
2002	0 136	0 149	0 132	179,391,974	$ 3,117,833
2003	0 139	0 153	0 135	179,344,173	$ 3,204,880
2004	0 142	0 156	0 137	179,180,893	$ 3,289,761
2005	0 145	0 159	0 140	178,902,135	$ 3,372,305
2006	0 147	0 162	0 143	178,507,899	$ 3,452,343
2007	0 150	0 165	0 146	177,998,183	$ 3,529,704
2008	0 153	0 169	0 148	177,372,989	$ 3,604,219
2009	0 156	0 172	0 151	176,632,317	$ 3,675,719
2010	0 159	0 175	0 154	175,776,166	$ 3,744,032
2011	0 162	0 178	0 156	174,804,537	$ 3,808,991
2012	0 165	0 181	0 159	173,717,429	$ 3,870,424
2013	0 168	0 184	0 162	172,514,842	$ 3,928,163
2014	0 171	0 188	0 164	171,196,777	$ 3,982,037
2015	0 174	0 191	0 167	169,763,233	$ 4,031,877

			DISCOUNT RATE =		12%
				NPV =	**$11,442,351**
	Revenue/ ASM	Revenue + 5%	Expenses/ ASM	ASM	CF
1985	0 085	0 089	0 083	156,876,000	$ 1,076,644
1986	0 083	0 087	0 081	176,289,474	$ 1,117,154
1987	0 088	0 092	0 084	169,157,801	$ 1,386,745
1988	0 094	0 099	0 089	171,900,596	$ 1,682,412
1989	0 101	0 106	0 099	173,572,843	$ 1,338,379
1990	0 104	0 109	0 106	172,725,318	$ 446,249
1991	0 105	0 110	0 108	168,669,521	$ 465,347
1992	0 104	0 109	0 107	173,827,400	$ 337,727
1993	0 110	0 115	0 108	172,393,908	$ 1,265,883
1994	0 113	0 118	0 109	171,956,533	$ 1,562,988
1995	0 117	0 123	0 110	171,160,637	$ 2,245,530
1996	0 122	0 128	0 115	177,774,340	$ 2,411,109
1997	0 127	0 134	0 117	182,139,830	$ 2,981,697
1998	0 124	0 130	0 121	178,428,393	$ 1,643,325
1999	0 127	0 133	0 124	178,842,506	$ 1,708,840
2000	0 130	0 137	0 127	179,141,141	$ 1,773,497
2001	0 133	0 140	0 129	179,324,297	$ 1,837,177
2002	0 136	0 143	0 132	179,391,974	$ 1,899,761
2003	0 139	0 146	0 135	179,344,173	$ 1,961,129
2004	0 142	0 149	0 137	179,180,893	$ 2,021,160
2005	0 145	0 152	0 140	178,902,135	$ 2,079,737
2006	0 147	0 155	0 143	178,507,899	$ 2,136,740
2007	0 150	0 158	0 146	177,998,183	$ 2,192,048
2008	0 153	0 161	0 148	177,372,989	$ 2,245,542
2009	0 156	0 164	0 151	176,632,317	$ 2,297,103
2010	0 159	0 167	0 154	175,776,166	$ 2,346,612
2011	0 162	0 170	0 156	174,804,537	$ 2,393,948
2012	0 165	0 173	0 159	173,717,429	$ 2,438,993
2013	0 168	0 176	0 162	172,514,842	$ 2,481,626
2014	0 171	0 179	0 164	171,196,777	$ 2,521,729
2015	0 174	0 182	0 167	169,763,233	$ 2,559,181

			DISCOUNT RATE =		14%
				NPV =	**$22,340,069**
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
1985	0 085	0 098	0 083	156,876,000	$ 2,413,022
1986	0 083	0 096	0 081	176,289,474	$ 2,583,484
1987	0 088	0 101	0 084	169,157,801	$ 2,872,681
1988	0 094	0 108	0 089	171,900,596	$ 3,301,566
1989	0 101	0 116	0 099	173,572,843	$ 3,096,382
1990	0 104	0 119	0 106	172,725,318	$ 2,239,549
1991	0 105	0 121	0 108	168,669,521	$ 2,237,853
1992	0 104	0 119	0 107	173,827,400	$ 2,142,112
1993	0 110	0 126	0 108	172,393,908	$ 3,155,039
1994	0 113	0 129	0 109	171,956,533	$ 3,499,169
1995	0 117	0 135	0 110	171,160,637	$ 4,251,281
1996	0 122	0 140	0 115	177,774,340	$ 4,581,802
1997	0 127	0 146	0 117	182,139,830	$ 5,300,024
1998	0 124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573

			DISCOUNT RATE =		10%
				NPV =	**$31,995,995**
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
1985	0 085	0 098	0 083	156,876,000	$ 2,413,022
1986	0 083	0 096	0 081	176,289,474	$ 2,583,484
1987	0 088	0 101	0 084	169,157,801	$ 2,872,681
1988	0 094	0 108	0 089	171,900,596	$ 3,301,566
1989	0 101	0 116	0 099	173,572,843	$ 3,096,382
1990	0 104	0 119	0 106	172,725,318	$ 2,239,549
1991	0 105	0 121	0 108	168,669,521	$ 2,237,853
1992	0 104	0 119	0 107	173,827,400	$ 2,142,112
1993	0 110	0 126	0 108	172,393,908	$ 3,155,039
1994	0 113	0 129	0 109	171,956,533	$ 3,499,169
1995	0 117	0 135	0 110	171,160,637	$ 4,251,281
1996	0 122	0 140	0 115	177,774,340	$ 4,581,802
1997	0 127	0 146	0 117	182,139,830	$ 5,300,024
1998	0 124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573

			DISCOUNT RATE =		8%
				NPV =	**$38,031,308**
	Revenue/ ASM	Revenue + 15%	Expenses/ ASM	ASM	CF
1985	0 087	0 099	0 086	162,536,374	$ 2,173,924
1986	0 089	0 103	0 089	164,451,708	$ 2,303,968
1987	0 092	0 106	0 092	166,251,564	$ 2,434,754
1988	0 095	0 109	0 094	167,935,941	$ 2,566,061
1989	0 098	0 113	0 097	169,504,840	$ 2,697,670
1990	0 101	0 116	0 100	170,958,260	$ 2,829,359
1991	0 104	0 119	0 102	172,296,201	$ 2,960,910
1992	0 107	0 123	0 105	173,518,664	$ 3,092,103
1993	0 110	0 126	0 108	174,625,649	$ 3,222,716
1994	0 113	0 129	0 110	175,617,155	$ 3,352,531
1995	0 116	0 133	0 113	176,493,182	$ 3,481,328
1996	0 118	0 136	0 116	177,253,731	$ 3,608,886
1997	0 121	0 139	0 119	177,898,801	$ 3,734,985
1998	0.124	0 143	0 121	178,428,393	$ 3,859,406
1999	0 127	0 146	0 124	178,842,506	$ 3,981,928
2000	0 130	0 150	0 127	179,141,141	$ 4,102,332
2001	0 133	0 153	0 129	179,324,297	$ 4,220,397
2002	0 136	0 156	0 132	179,391,974	$ 4,335,904
2003	0 139	0 160	0 135	179,344,173	$ 4,448,632
2004	0 142	0 163	0 137	179,180,893	$ 4,558,362
2005	0 145	0 166	0 140	178,902,135	$ 4,664,873
2006	0 147	0 170	0 143	178,507,899	$ 4,767,946
2007	0 150	0 173	0 146	177,998,183	$ 4,867,360
2008	0 153	0 176	0 148	177,372,989	$ 4,962,896
2009	0 156	0 180	0 151	176,632,317	$ 5,054,334
2010	0 159	0 183	0 154	175,776,166	$ 5,141,453
2011	0 162	0 186	0 156	174,804,537	$ 5,224,034
2012	0 165	0 190	0 159	173,717,429	$ 5,301,856
2013	0 168	0 193	0 162	172,514,842	$ 5,374,700
2014	0 171	0 196	0 164	171,196,777	$ 5,442,346
2015	0 174	0 200	0 167	169,763,233	$ 5,504,573