Forecasting aircraft values: An appraiser's perspective

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To paraphrase Nils Bohr, a Nobel laureate in Physics, "Forecasting is difficult, especially if it's about the future." Obviously, it is difficult to provide accurate forecasts because past trends and relationships are not always a good indicator of future behaviour. Life is full of unpredictable events that can challenge even the best forecaster.

At AVITAS, we use a blend of approaches to derive our future value opinions which include Future Base Values and Future Market Values. The primary difference between Base and Market is that Base Value is the underlying economic value of an aircraft assuming balanced supply and demand, while Market Value is the actual trading price of the aircraft under market conditions that exist at that time.

Our value definitions conform to those of the International Society of Transport Aircraft Trading (ISTAT) adopted in 1994, and a full description of each definition can be found at the end of this article.

The purpose of this article is to introduce the reader to our two primary methodologies used in forecasting aircraft values. These complementary methodologies are what we refer to as the "traditional approach" and the "econometric modelling approach".

The traditional approach. All other things being equal, aircraft values depreciate over time due to ageing structures that require an increasing amount of maintenance. Also, an aircraft will suffer from increased weight and drag due to dirt and repairs over its life.

These things along with a growing obsolescence due to the introduction of new technologies and improvements in fuel burn and other operating costs will contribute to the depreciation process and limit an aircraft's economic useful life.

Although an aircraft's structural life is indefinite (as long as it is maintained properly), its economic life ends when it can no longer generate a positive discounted cash flow (in other words, it is cheaper to replace or scrap the aircraft than to continue maintaining it).

We can look to historical transaction data as support of this concept of depreciating value. The AVITAS historical

Table 1: Nominal values vs. age (for all commercial jets)

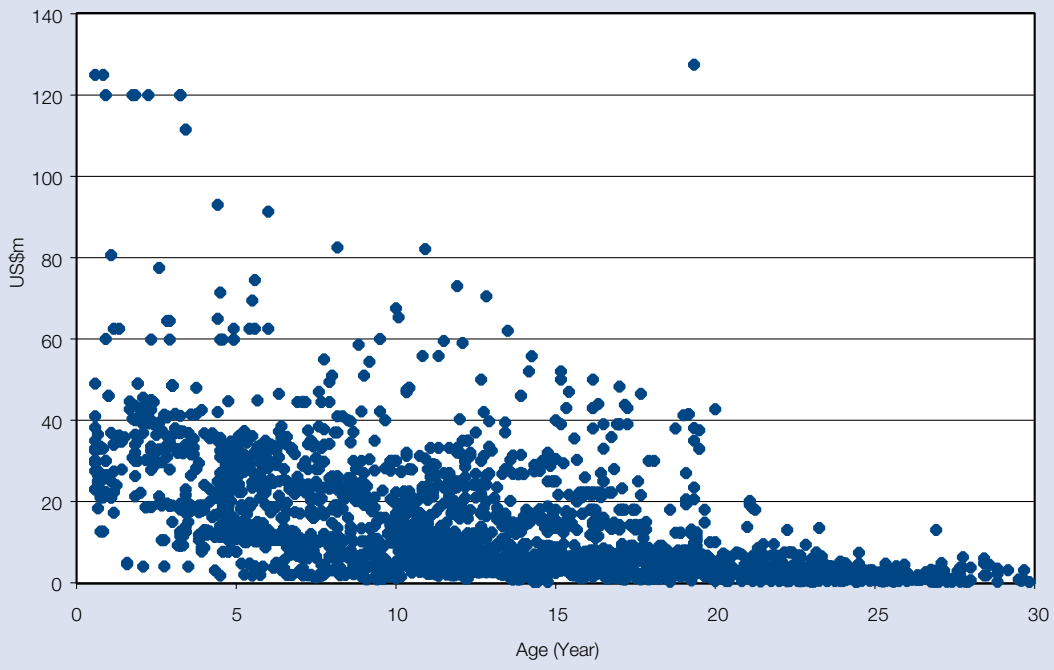
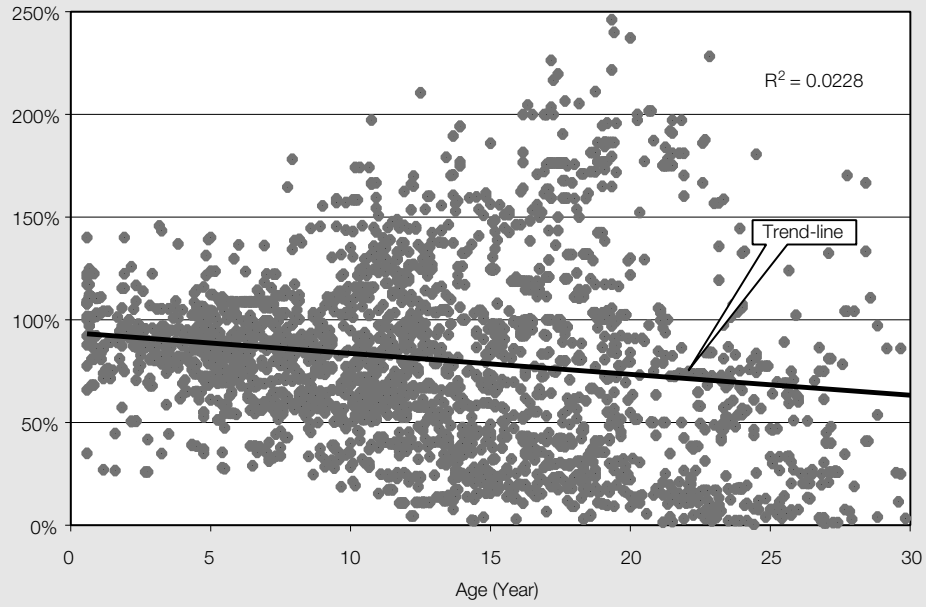


Table 2: Nominal value as a percentage of original value (for all commercial jets)



transaction database has over 3,000 resale data points from 1970 to present. However, when we try to plot our transaction data for all jets on the same chart, we encounter a couple of problems (see Table 1).

Looking at Table 1, it is difficult to discern any relationship of value and age. This is because the chart includes all aircraft types such as B747s and DC-9s which have very different prices. A B747 may sell for US$100m while a DC-9 may sell for US$15m at the same age. Therefore, in order to remove this distortion, it is necessary to plot the historical transactions as a percent of original cost (see Table 2).

Now, we can use simple regression analysis and plot a line of best fit through the data points to understand the cause-and-effect relationship between age and price. The coefficient of determination (R^2) is a statistical measure that allows us to determine how certain one can be in making predictions with this regression line.

It is obtained by squaring the value of the correlation coefficient. The coefficient of determination is greater than or equal to 0 and less than or equal to 1. An R^2 close to 1 means that the independent variable, in this case age, is very good at explaining the dependent variable, value.

As you can see in Table 2, the R^2 is 0.0228 which means that only 2% of the variance in an aircraft's residual value

Table 3: Real value as a percentage of real original value (for all commercial jets)

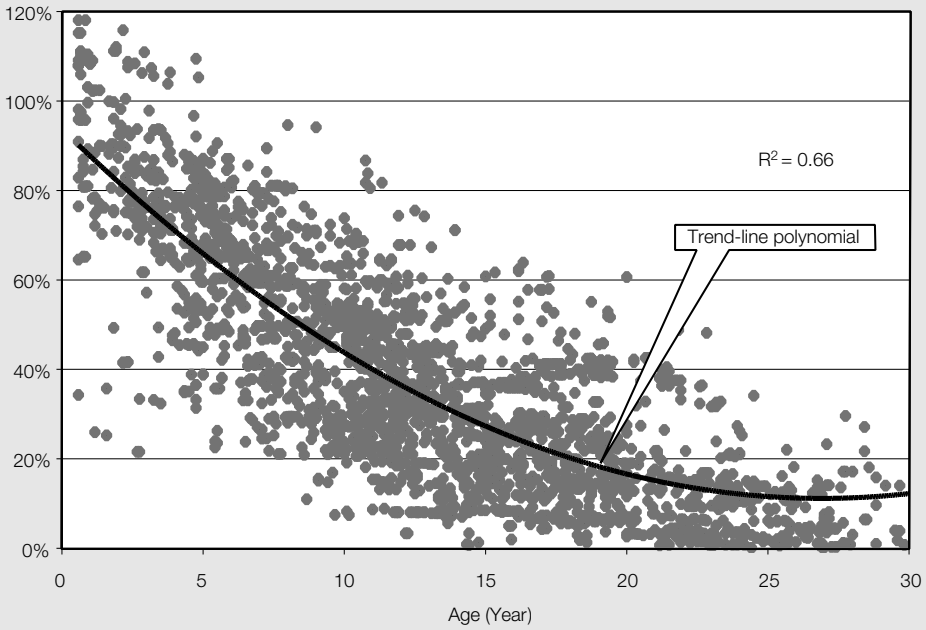
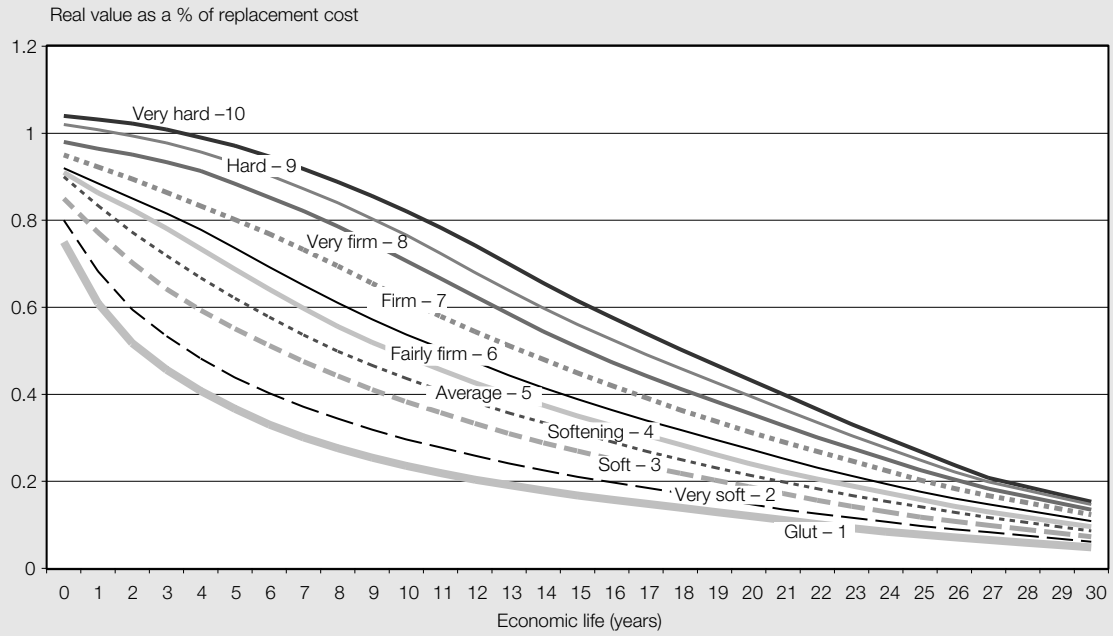


Table 4: Traditional approach ("market-strength bands")



can be explained by age. However, by expressing the data in "real" terms, that is, by removing the effect of inflation, we can improve the correlation. Furthermore, we found that a polynomial trend-line proved a better fit than a linear regression. Together, these adjustments improved the R^2 to 0.66 (see Table 3).

Thus, we can conclude that age alone can explain 66% of the variance of an aircraft's residual value.

Both the traditional approach and the econometric modelling approach are founded on this historical relationship. As we will see later, the econometric approach takes the quantitative analysis further by introducing additional independent variables into a multi-regression model and by considering the effect of the cycle on values.

The traditional approach uses the AVITAS transaction-based trend model which stratifies aircraft into "market-strength bands". These baseline forecast curves are depicted in Table 4.

While the 10 market-strength bands have been categorised from very hard (10) to glut (1), there are really an infinite amount of bands between these primary curves.

The appraiser will analyse each aircraft model to determine its historic, current and projected competitive position with respect to similar aircraft types in terms of mission capability, economic profile and market penetration.

As a result of weighing those factors, we assign a numerical "strength" to each aircraft for each year of its economic life, where Strength 10 represents the strongest value performance and Strength 1 the weakest.

The model then translates those strength factors into the aircraft's Base and Future Base Values based on its actual replacement cost (or theoretical replacement cost if it is no longer in production). We constantly monitor our value opinions and because of the dynamics of the aircraft marketplace and our continuing recalibration, Base Value opinions are not static.

As an example, let us examine three competing models: MD-83, B737-400 and the A320-200. These narrowbody aircraft were introduced in the mid-to-late 1980s and operate in the 150-seat medium-range market. Both the MD-83 and B737-400 have been out-of-production since 1999 while the A320-200 is still in production.

A summary of the various factors that an analyst must consider is presented in Table 5.

While each aircraft when new starts out on an 8.5 curve (100% of new replacement cost), its mature curve is typically lower and is subject to change over time depending on how the key factors change.

Because we believe the A320-200 has technological, operational and economic advantages over the B737-400 and MD-83, we have assigned it the highest value curve of the three types. The A320-200 is on a 6.0 curve, followed next by the B737-400 at 5.0, and finally the MD-83 at 3.0. The MD-

Table 5: Key factors

Aircraft size/range	Number in service/on order
Speed	Number of operators
Engine type	Concentration of operators
Technology	Geographic distribution
Direct operating costs	Number available/stored
Reliability	Manufacturer status
Convertibility	Competing types
Commonality	Government regulations
In or out of production	Market forecasts

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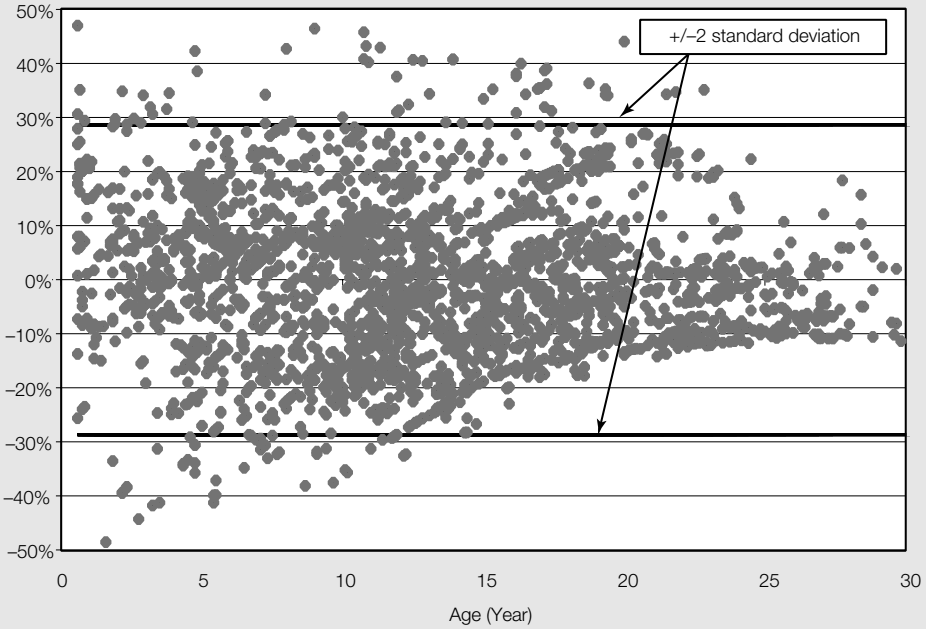
Table 6: Statistical residual – all jets (independent variable – age only)



83 suffers from a smaller and concentrated operator base, higher relative fuel burn, and a manufacturer that is no longer in the commercial business (McDonnell Douglas was acquired by Boeing in 1997).

The computer model then converts these value curves into Base and Future Base Values depending on each aircraft's economic life assumption and its replacement cost (or theoretical replacement cost for out-of-production aircraft). As mentioned previously, we constantly monitor our opinions and make adjustments to the value curve, replacement cost or economic life assumption depending on our estimates for future value behaviour.

The econometric approach. While the traditional approach is helpful in forecasting Future Base Values, it lacks the capability to forecast Future Market Values.

The "Econometric Approach" allows us to introduce additional independent variables into our model and incorporate the effect of the cycle on our future value opinions.

Table 7: Statistical residual – all jets (independent variables – age, plane characteristics and customer related)

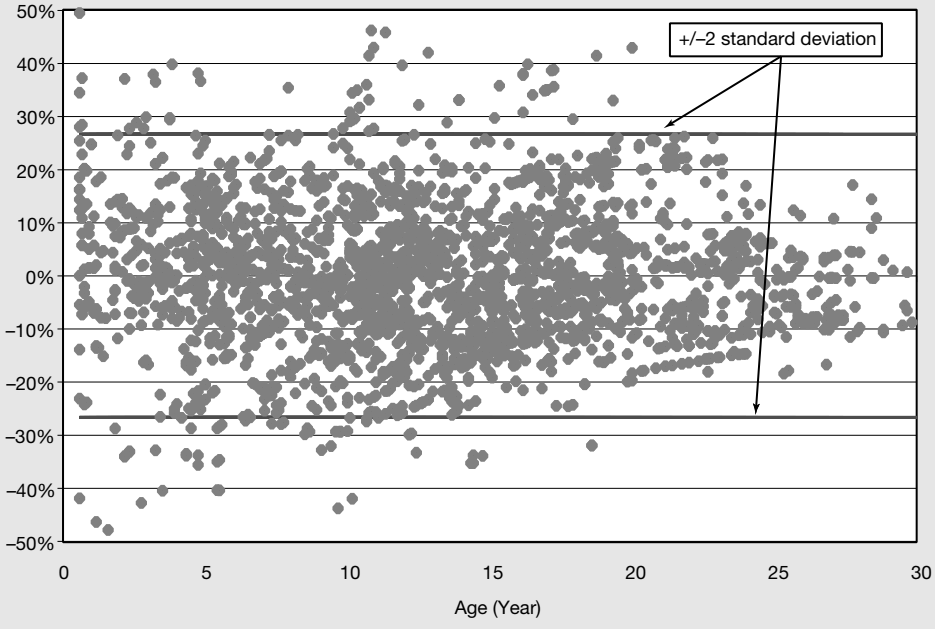
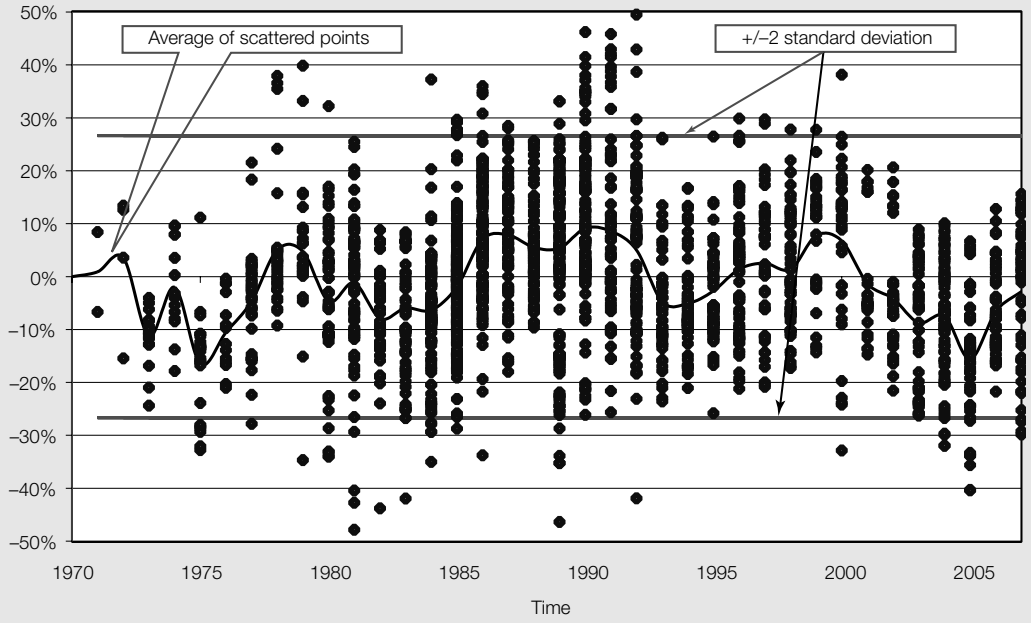


Table 8: Statistical residual – all jets (independent variables – age, plane characteristics and customer related)



This approach was especially useful after 9/11 when values changed significantly and our customers wanted to know answers to the following questions: (1) how far have values fallen?; and (2) when will the values recover? Since there were no secondary market transactions for months after 9/11 (other than for part-out or deals that originated before 9/11), the traditional approaches used by appraisers were not very helpful.

At AVITAS, we accelerated the development of our econometric modelling techniques and used this tool to publish our Special Edition BlueBook and Global Outlook for Air Transportation (GOAT) in November 2001.

Econometric modelling is well suited for scenario analysis such as 9/11-type situations and volatility analysis. It also has other advantages such as objectivity, transparency and reproducibility.

Table 9: Statistical residual – all jets (all variables including economic and regulatory variables)

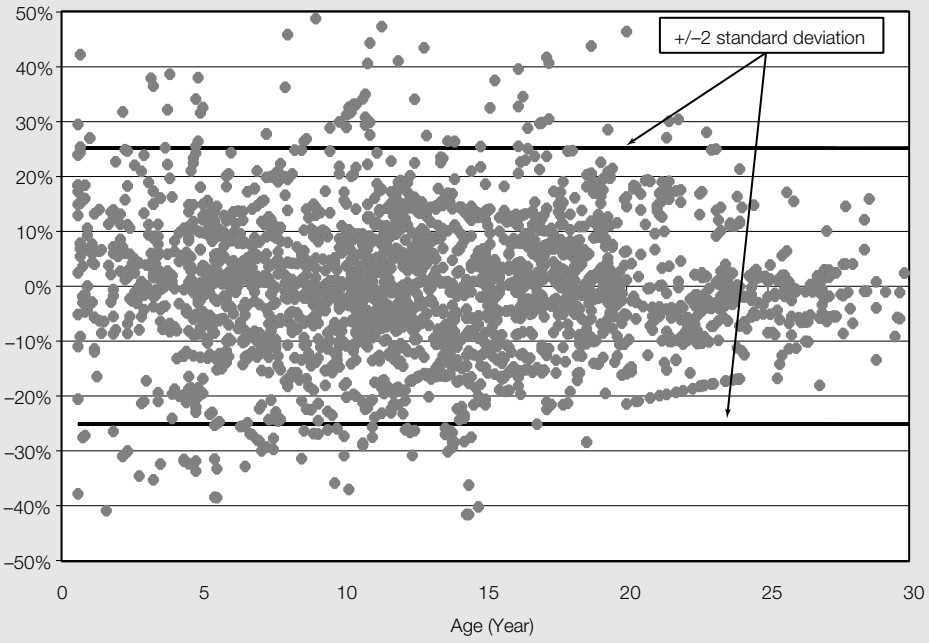
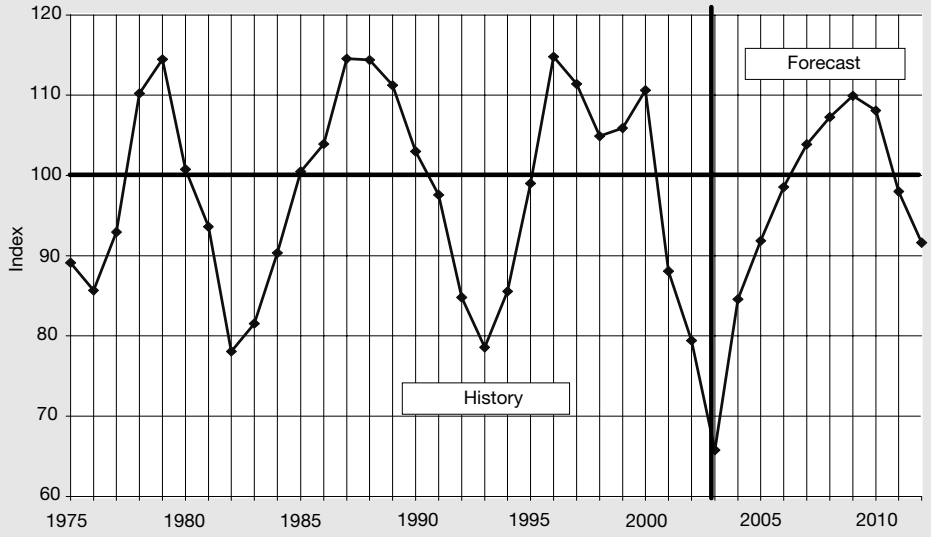


Table 10: Value index for all commercial jets (history and forecast)



Of course, it has disadvantages as well. The data are not perfect and do not always behave based on our experience, some things are difficult to measure and the modelling can produce ridiculous results. Because of these disadvantages, it may be necessary for the analyst to impose his or her judgment into the model and make reasonable assumptions when required.

As mentioned previously, while the Econometric Approach is an alternative methodology it is also complementary to the Traditional Approach. As we determined in Table 3, age, inflation and original cost all matter when developing a transaction-based model. We were able to increase the coefficient of determination of the regression line to 0.66 by removing

Value definitions

AVITAS's value definitions conform to those of the International Society of Transport Aircraft Trading ("ISTAT") adopted in January 1994 and are summarised below:

- **Base Value** is the appraiser's opinion of the underlying economic value of an aircraft in an open, unrestricted, stable market environment with a reasonable balance of supply and demand and assumes full consideration of its "highest and best use". An aircraft's Base Value is founded in the historical trend of values and in the projection of value trends and presumes an arm's-length, single-unit, cash transaction between willing and knowledgeable parties, acting prudently, with an absence of duress and with a reasonable period of time for marketing. Base Value typically assumes that an aircraft's physical condition is average for an aircraft of its type and age, and its maintenance time status is at mid-life, mid-time (or benefiting from an above-average maintenance status if it is new or nearly new).
- **Market Value** (or **Current Market Value** if the value pertains to the time of the analysis) is the appraiser's opinion of the most likely trading price that may be generated for an aircraft under the market conditions that are perceived to exist at the time in question. Market Value assumes that the aircraft is valued for its highest, best use, that the parties to the hypothetical transaction are willing, able, prudent and knowledgeable, and under no unusual pressure for a prompt sale, and that the transaction would be negotiated in an open and unrestricted market on an arm's-length basis, for a single unit, for cash or equivalent consideration, and given an adequate amount of time for effective exposure to prospective buyers. Market Value assumes that an aircraft's physical condition is average for an aircraft of its type and age, and its maintenance time status is at mid-life, mid-time (or benefiting from an above-average maintenance status if it is new or nearly new). Market Value is synonymous with Fair Market Value in that both reflect the state of supply and demand in the market that exists at the time.

the effect of inflation. Another way of viewing the results of Table 3 is shown in Table 6.

The 0% line represents the line of best fit from Table 3. The plot points are called "residuals" and are also referred to as the errors of the model. A residual is just the difference between an actual observed y value (data point) and the corresponding predicted y value (regression line). The solid lines indicate that 95% of all the data points lie within two standard deviations of the mean.

By introducing additional independent variables such as airplane characteristics (e.g. size, range, speed, engine, technology and doc) and customer-related variables (e.g. number in service, operators, concentration, commonality and transaction size), we can reduce the variance and thus improve the predictability of the model (see Table 7).

Now, by plotting the residuals over time instead of age, we can begin to discern a pattern resembling the economic cycle. The black line represents the average of the scattered points in that year (see Table 8).

The evidence of a residual pattern among the data points may indicate that the model can be improved by introducing additional variables. In this case, if we include macro-economic variables (e.g. growth rates of RPMs and ASMs, fuel price, aircraft availability and government regulations), we can further reduce the variance of the model (see Table 9).

It is this approach that led to publishing the first value index chart in the *Special Edition GOAT* book in November 2001. This chart was updated and revised slightly in the following editions based on the additional negative events that followed the tragedy of 9/11 such as the Iraq War, SARS and the Chapter 11 bankruptcies of US Airways and United Airlines.

Table 10 presents the value index curve that was published in the 2004 *GOAT* book for all commercial jets from 1975 along with a 10-year forecast from 2003 to 2012. The value index of 100% means the value of the aircraft is determined by variables excluding the cyclical disturbances. By taking into account the impact from cyclical variables, such as RPM growth and aircraft surplus, we can calculate the deviation from the 100% baseline as a percentage of the residual value of the aircraft.

How accurate has this model been? As you can see in Table 10, AVITAS predicted a return to "Base Value" for most types by approximately 2006 and a peak in the next cycle around 2009. How has the AVITAS forecast changed? The 100% increase in the price of fuel from 2007 to 2008 (currently US$135 per barrel) is clearly one of those unpredictable events that can change a forecast. This has caused us to move up our prediction of the peak in values to January 2008.

The recent announcement of the US legacy carriers to phase out a large number of MD-80s, B737 classics and small regional jets will drive those values down deeply and quickly. The A320s and B737 Next Generation aircraft values should hold up better and only suffer a slight decline because of their lower operating costs and performance advantages over the older technology aircraft. The in-production widebody aircraft should hold up much better than narrowbodies due to the delays in the A380 and B787 deliveries. Also, with the revamped A350XWB not due to deliver until 2013, widebody aircraft will be in short supply which should keep values relatively firm for the near term.

Conclusion. AVITAS uses a blend of approaches to forecasting values. Our traditional approach uses a transaction-based trend model which stratifies aircraft into "market-strength bands". Based on thousands of actual market transactions, the model sets forth a series of value curves which describe the value behaviours of aircraft under different circumstances.

The econometric approach can provide an alternative method of obtaining residual values. It is a multi-regression model that allows us to incorporate the effect of the cycle on values. This type of method is naturally suited for scenario and volatility analysis.

While these are alternative approaches, they are also complementary. Both approaches can be useful to the appraiser in forecasting values but require sound judgment, analytical rigour and a solid understanding of the airline industry.

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