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# Theory and Practice in Aircraft Financial Evaluation

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## Abstract

This paper explores the state of practice regarding aircraft financial evaluation. Traditional measures of aircraft economic viability, including Direct Operating Cost (DOC) comparison, ignore both the non-cash elements of costs, and the time value of money. Practitioners adopting more advanced techniques often go straight to the Net Present Value calculation using an "industry standard" discount rate, ignoring critical problems such as estimating the cost of capital, quantifying the highly uncertain economic environment airlines face, and valuing the flexibility offered by manufacturer options and operating leasing. We propose taking advantage of the potential flexibility of the NPV approach by close attention to the choice of discount rates to flesh out investment/financing interactions, use of Monte Carlo analysis to quantify risk up front, and Real Options Analysis (ROA) to better understand the value of flexibility to aircraft operators.

## Key words

Capital budgeting, investment analysis, aircraft evaluation, NPV, ROA

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## 1. The changing sources of airline capital

In many countries, airlines have historically been viewed at least partially as an infrastructure investment, required to promote economic development and growth. This implies that for many governments airline financing can be viewed as part of the state's overall infrastructure financing. Further, because of the strategic and military background of aviation, many of the world's airlines were initially financed using state funds. In this historical perspective, the cost of financing investment in aircraft is the government's own cost of financing, which depends on the willingness (or obligation) of taxpayers to provide interest-free financing, and the interest rate on government debt.

The latter will be determined by investors' assessment of the state's creditworthiness, often based on work by rating agencies such as Moody's Investor Service, Fitch, and Standard and Poor's.

The notion that national governments should fund aircraft investment out of general revenues to support overall economic development, rather than to produce profits, is contradictory to the current view of airlines as generators of economic wealth. Financiers correctly point out that the relatively low cost of government financing can encourage dramatic over-investment, when the airline is competing against profit-oriented airlines in the international arena. However, a huge amount of airline equity remains in the hands of governments around the world. Among the world's alliance members, the state is the largest shareholder in 45% of the airlines alliance members surveyed by Airline Business (2002).

Most of the world's airlines today seek to make increased use of capital market financing. The wave of privatisation is reaching into every part of the globe. China Eastern, Thai International, China Southern in Asia, and LAN Chile in South America are just a few examples of airlines partially or fully privatised in the last 20 years.

The most dramatic wave of privatisation has been in Western Europe, British Airways, Iberia and Lufthansa have all been fully privatised. In any case, state-owned airlines rarely receive capital for expansion from their governments. In addition, start-up airlines with sound business plans are finding private capital readily available. Notable examples are India's Sahara and Jet, not to mention such fast-growing start-ups as easyJet and Ryanair in Europe, JetBlue in the United States, and AirAsia in Malaysia.

This unmistakable trend toward the use of private capital points up clearly the need for a solid and transparent financial justification for the large investments needed to support growth and profitability in the future.

## 2. Aircraft economic evaluation

Analysts and academics agree that cash-based measures provide the soundest indicator of investment viability, if for no other reason than the fact that investors are putting up cash, and demand a cash return from the project. However, the most common cost element used to compare aircraft in terms of economic performance remains Direct Operating Cost (DOC), which reflects a Profit and Loss (P&L) approach, including non-cash items such as aircraft depreciation. Moreover, DOC averages critical costs such as training, financing, and maintenance over the aircraft life, rather calculate them on an as-incurred basis. Finally, the notion of the time value of money is absent in this analysis.

When using cash-based investment appraisal tools such as NPV, there is a strong temptation to compensate for the volatility of the industry by artificially increasing the discount rate used in the analysis, thus making the project more difficult to justify. This approach has the serious disadvantage of "funnelling" all the risk through the discount rate, and also reduces the value of the analysis itself: a fundamental task of management is to deal with risk effectively rather than "insuring it away" by using an artificially high cost of capital.

We suggest that a better approach to uncertainty is to use a moderate cost of capital, either using market measures such as Lufthansa has done, or alternatively, using broad, long-term regional benchmarks such as those identified in Dimson, Marsh and Staunton (2002). We then capture cash-flow volatility using Monte Carlo simulation, calculate *Expected* NPV and the probability of success, and extend the investment analysis using Real Options Analysis.

## 3. Operating lease vs. purchase analysis

Operating leasing has undeniable benefits for operators of aircraft, offering a level of fleet flexibility and residual value risk reduction unobtainable when purchasing. Growing far beyond their origins as a "cheap" – or more accurately, low initial cash-out - solution to aircraft finance, operating leases are the financing vehicle of choice for around one quarter of all new large civil aircraft delivered today, extensively used today by the world's largest airlines. Companies use operating leases for flexibility when adopting a new aircraft type. For example, British Airways has financed 10 of its 15 A320 family fleet under 10-year extendible operating leases. Conversely, operating leases can form part of an aircraft type exit strategy, as in the case of Singapore Airlines' 747-400 fleet. The aircraft are financed under leases running from 4-10 years, with 2-year extension OPTIONS and full sub-leasing rights.

A correct discounted cash flow (DCF or NPV) analysis of leasing vs. purchasing should at least estimate and include the cost of the flexibility benefits offered by operating lessors, when compared to debt financing. The classic pitfall in using NPV for aircraft investment analysis is including and comparing the operating lease cash flows in the analysis, and comparing the result against the purchase cash flows. In aviation accounts, operating lease payments are viewed as operating costs, while interest is presented below the operating profit line. Economically, lease payments include both investing and financing cash flows, as well as a risk premium for the lessor.

When the cash flows are discounted at the Weighted-average cost of capital (WACC), the result is almost inevitably often favourable to leasing because of the large up-front investment in purchasing, and places undue emphasis on aircraft residual values. Viewed graphically, the differences are apparent, as Figure 2 shows. This problem is discussed from a theoretical standpoint in Myers (1974), Myers, Dill, Bautista (1976), Copeland and Weston (1982), and applied to aviation in Stonier (1998).

Leasing is fundamentally a financing vehicle, and should be compared with the costs of borrowing or taking on a finance lease (known in the U.S. as a capital lease). To correctly estimate the cost of leasing, we recommend using a variant of the well-documented Adjusted Present Value concept. Under APV, cash flows of different risk classes are discounted at the discount rates that reflect the risk class of the cash flows. This method is discussed from a theoretical standpoint in Myers (1974), Myers, Dill, Bautista (1976), Copeland and Weston (1982), Copeland et al., 2000. Our experience suggests that it has yet to be fully understood and adopted in aviation industry practice.

Our proposed extension of the APV method is straightforward, consisting of discounting the lease payments and loan repayments at the cost of debt to quantify the cost of leasing flexibility, and discounting the high-risk investing and operating cash flows at the cost of equity reflecting the shareholders' risks.

This approach clarifies two major points that are lost in a WACC-based NPV

- the risks of owning and operating aircraft are borne by the equity investors

- the extraordinary flexibility of operating leases has a quantifiable cost to operators of aircraft

We thus propose taking a step beyond classic APV, where only the tax deductions on interest payments are discounted at the cost of debt, capturing leverage benefits. We suggest that just as WACC has been thoroughly accepted in spite of its theoretical pitfalls and the difficulty in estimating cost of equity, this variant of APV should be examined and adopted to compare leasing versus purchasing in an NPV framework.

When it comes time to finance deliveries, aircraft finance specialists recommend that operators discount the term sheets offered by different financiers to determine the best offer. Our approach to investment analysis using APV extends this tactical approach to long-term strategic investment analysis.

A final practical problem in comparing leasing and purchasing concerns the investment horizon. Operating leases are generally less than ten years in length, and are often three, five, or seven years, with or without options to extend. To properly compare leasing and purchasing over a longer term, it is necessary to assume that a lease is renewed over the investment horizon. Methods used to re-price the lease after the primary period range from simply assuming that the lease rate will remain fixed, to modelling the variation in lease rates as a function of aircraft values.

As the worked example in Figure 2 illustrates, the differences in valuation are clearly significant. First, APV results in a lower overall evaluation because the operating cash flows are discounted using the higher equity rate. Second, the purchase scenario APV is $2.4m higher than operating lease, reflecting the cost of the residual value risk transfer to the lessor.

## 4. Valuing bottom-line returns to investors

In the classic theoretical and management literature, the investment and financing decisions are kept strictly separate. On the other hand, airline stakeholders need to understand the overall costs and benefits of investing.

For this purpose, the Equity NPV concept used in project finance builds on the notion of clearly distinguishing the cost of debt, and the cost of equity. All project cash flows – investing, operating, and financing – are discounted at the cost of equity.

The resulting value shows the result of the investment from the shareholders' point of view, including the leverage benefits from debt financing, and obviating the distinction between leasing and purchasing.

Since tax is a very important consideration for most private investors, this analysis requires an after-tax approach. As with APV, the differences in valuation are substantial, and the underlying assumptions and implications need to be clearly understood by managers.

## 5. Summarising and comparing valuation methods

Each method answers a different, critical question.

- NPV measures the fundamental return on the investment, assuming the project is financed using the firm's overall capital resources at a target debt and equity mix.
- APV clearly separates cash flows into different risk classes, and measures the cost of residual value risk transfer to the operating lessor.
- Equity NPV shows the bottom-line returns to the investors, including the leverage benefits of the financing.

## 6. Dealing with uncertainty in aircraft investment planning

The past three years have clearly demonstrated that the greatest challenge for airlines today, which can make the difference between success, and failure is dealing with unexpected shocks in the economic environment.. Two of the most prominent trends over the last 15 years in aircraft investment planning have been reductions in manufacture lead-times which increase airline flexibility to convert from one aircraft type to another before delivery, and the increased use of operating leasing by airlines of all sizes and locations.

Both innovations help airlines cope with the uncertainties they face in operating aircraft. Financial theory provides the means to value these benefits, which can then be incorporated directly into the cost of the financing overall on a strategic basis, rather than deal-by-deal or delivery-by-delivery. However, the theory of options seems very arcane to managers when it is not broken down into usable steps.

We propose two complementary approaches that take advantage of the potential flexibility of the NPV approach to better understand investment dynamics on the one hand, and the application of Real Options Analysis (ROA) to better understand the value of flexibility to aircraft operators on the other.

## 7. Uncertainty in the cash flows: the Expected NPV concept

The NPV methodology is well documented and widely taught, and has the advantage of being relatively easy to explain and intuitive. On the other hand, practitioners suffer from a tendency to inflate the discount rate artificially, to "insure" against risk, a practice which completely ignores upside potential. We propose to capture the risk of airline cash flows in a different way, by extending the concept to an "*Expected NPV",* similar to the familiar statistical concept of Expected Value, where outcomes are weighted by probabilities.

To do this we use Monte Carlo analysis, a well-proven statistical technique that has earned a key place in airline investment planning. The Monte Carlo simulation is built on top of a cash flow model, which calculates NPV. Uncertainties in the operating environment are estimated using probability distributions. Good examples of risky items in aviation include fuel prices, and exchange rates, traffic growth and yields, maintenance costs, and overall cost inflation rates. Estimates of probability distributions for these items may be derived from historical data, management judgement, or a combination of the two. The exercise of estimating distributions has the benefit of encouraging managers to think in terms of uncertainty at the beginning of the analysis.

The NPV model is then run hundreds or thousands of times. For each trial, a discrete value is assigned to each input variable according to the assigned probability distribution. An outcome (NPV) is generated, and added to the data set.

The output of the analysis is a range of possible NPVs, including an *Expected NPV* (the mean outcome). In addition, standard measures of dispersion around the mean are calculated. A probability of a positive NPV can then be readily calculated, adding a new dimension to the analysis and management discussion.

Taking a very well known – and volatile – example from aviation, Figure 3 shows the pattern of fuel prices in the 1990s.

In classic NPV, companies tend to use point input prices, implicitly assuming that these prices are predictable. In *Expected NPV*, we recognise that there is significant uncertainty in prediction. Not surprisingly, this type of analysis creates new challenges: management is directly confronted with the need to quantify and manage uncertainty, and to accept that the decision to invest is made knowing that there is a calculable uncertainty of success, a notion not to the taste of managers keen to sell investment projects to senior management and Boards of Directors.

This is particularly uncomfortable for management cultures that do not readily accept uncertainty. The framework of analysis is shifted to a risk management approach, which is inherently less comfortable than the "yes-or-no" outcome of NPV analysis.

## 8. Using Real Options to value flexibility

Clearly, the NPV approach to investment planning is useful as part of the analysis. Even our proposed APV extension provides only a theoretical valuation of the flexibility offered by lessors and manufacturers that offer purchase and aircraft conversion options.

Real Options Analysis (ROA) builds on *Expected NPV*, providing new insights into the value of flexibility: APV can measure the financial *cost* of flexibility, whereas Real Options measures the *value* of flexibility in investment planning.

Options pricing theory was introduced by Fischer Black and Myron Scholes in 1973, and has been used since then to price financial options on shares, commodities, currencies, and interest rates. Real Options applies this basic framework to the pricing of options on real assets, such as aircraft. These can be Call options such as purchase options and aircraft family conversion options, or Put options such as extendible operating leases, aircraft return windows or residual value guarantees.

Options pricing is a curious blend of intuitively correct - even obvious - value drivers, rather abstruse mathematics, and very large assumptions about the similitude of real assets and financial assets.

The theory and practice of real options valuation is extensively discussed in Copeland (2001), Mun (2002). Stonier (1999, 2001) applies the concept to aircraft option valuation. What is needed to apply the concept in practice is an intuitive, or graphical "hook," which we find in the binomial lattice, a set of potential outcomes to the project built using the variance of returns from our *Expected NPV* under Monte Carlo. Key inputs to build the lattice are the standard deviation of returns given uncertainty, and the number of “steps” or branches in the binomial lattice. Hence, Real Options can be viewed as an extension and improvement on *Expected NPV*, itself a great advance beyond simple, deterministic NPV.

The binomial lattice is a convenient way to represent the uncertainty present in a dynamic market like air transport, as Figure 4 demonstrates. Around the straight line Expected NPV, upside and downside potential are present in this more realistic view of the potential for value creation.

Notwithstanding certain methodological barriers, Real Options provides insight into the costs and value of intangibles like aircraft family conversion options, and operating leases. It is a method that quantifies and prices the intuitive advantages of “looking before you leap.”

## 9. Using ROA to value an aircraft family conversion option

To demonstrate the technique, we will use the example of a family conversion option, known in the options jargon as a “switching option.” Manufacturers of aircraft offer airlines the possibility to convert between members of an aircraft family before delivery, given a firm order. In our example we will value the option to switch from an Airbus A320 with 150 seats, to an A321 with 175 seats.

Intuitively, we realise that the A321 investment acquires value if airline traffic and yield conditions are favourable. Since these two variables are highly unpredictable, options pricing takes us beyond the intuition to the understanding that the option to choose *itself* has considerable value for airlines, whether traffic and yields increase *or* decrease.

To value the option, we set up a cash-flow model, with one scenario for the A320, and another for the A321. Each aircraft has its particular capacity for passengers and cargo, and its trip cost structure as a basic input. In the model, we simulate the operating environment: traffic demand, spill factor, revenue yields, and fuel costs are among the key inputs.

Next, we associate probability distributions with the key uncertain inputs to the model. In our stylised example, we will simulate uncertainty in basic demand for seats and fuel prices. Seat demand is set using a most likely demand for 150 seats, with downside potential of demand for only 110 and upside up to 165: zero overall traffic growth is assumed in our simplified example. Fuel price uncertainty is simulated using the historical analysis presented above.

Running the Monte Carlo simulation, we discover that the A320 returns carry (for example) a 6% standard deviation, and A321 returns carry a 7% standard deviation. This is intuitively correct, since a larger shell size will carry more upside potential, but more risk as well.

The standard deviations are used to build a binomial lattice of possible NPVs. At each node of the lattice, the model compares the NPV of acquiring and operating the A320 with that of the A321. If we choose to exercise the A321 option, an assumed switching cost of $500,000 is incurred for spares, training and other Entry into Service (EIS) costs for the new type. The NPV of the A321 must therefore exceed the A320 NPV by more than this $0.5m cost, or we will stay with our original order of the A320. In our five-step example with sigmas of 6%/7%, the lattice of decisions based on our assumptions is represented in Figure 5.

In nine of the simulated potential states of nature in which conditions in the air transport market are relatively good, we will exercise the option to convert to the A321. If conditions are consistently bad over the period the option remains open, there are 12 outcomes under which we will stay with the A320.

To value the option at contract signature, we must reason *backward* from the deadline to exercise the option in the future, to today. At deadline, we will maximise our benefit (NPV) by choosing the A320 or the A321. At each *preceding* node in the lattice, we will either exercise the option to convert to the A321, or we will keep the option open. The option value at each node as we move backward to today is thus the greatest of the A321 NPVs less the switching cost and the expected value of the subsequent nodes, discounted back at the risk-free rate to compensate for the time value of money.

The value of the flexibility during the option period (the option price) is the single value at the root of the lattice, minus the NPV that we expect from the aircraft. In our example, the value is nearly $125,000. This is a measure of the value inherent in flexibility offered to the airline, consistent with valuation methods used throughout the world, and built on well-established statistical and mathematical theory.

## 10. Methodological challenges of Expected NPV and Real Options Analysis

*Mean reversion and autocorrelations in cash flows* can create erroneous results in both Expected NPV and ROA valuations. In a cyclical industry, many inputs tend to correct themselves over the cycle, reverting to a long-term trend or average. Mean reversion in aviation markets is discussed in Stonier (1999). Further, there may be correlations between the behaviour of input variables. A notable example is the relationship between aircraft market values and operating lease rates. The validity of postulating correlations between input variables needs to be further examined, and clear limits determined.

*Estimating the project volatility* is another question mark for practitioners. In one method, managers are asked to accept the postulate that real asset values can be approximated by comparing them with listed firms, a rather tenuous proposition, and it is unusable in less open securities markets, where share prices are not readily available. In another, the volatility of projects with significant negative cash flows in extended periods cannot be calculated accurately, due to the impossibility of calculating a natural logarithm of a negative number. Five potential methods are dissected in Mun (2002). We use the logarithmic present value approach in our modelling, and have found no significant practical difficulties.

Both NPV and ROA are subject to the assumption of a *constant discount rate throughout the project*. Turner and Morrell (2002) and others have pointed out that discount rate estimates are variable, and clearly, companies' costs of capital vary over time. This is an excellent example of volatility in the market, and yet, the value is left constant in NPV. In ROA, a constant rate is used to calculate project volatility in the logarithmic present value method. No completely satisfactory solution to this problem is available.

*Time vs. steps in the binomial lattice* is another practical challenge. The outcome of the lattice is a set of states of nature, all expressed in NPV. The number of terminal nodes in the lattice depends on the number of steps used in the analysis, which is not the same as the time to expiry of the option. On the other hand, the nodes of the lattice are discounted back to determine the option value, implying that the potential NPVs become known in the future. Understanding the relationship between the steps and nodes on the one hand, and the time and decision points between contract and expiry on the other, is rather arduous for practitioners. Unlike the fundamental options value drivers, it is not at all intuitive.

Financial evaluation is an important part of airline fleet planning, but it is just one part of a very complex strategic process. Airline managers do not have infinite time to dedicate to learning how to value options. Mastery of the advanced stochastic methods used is rare enough outside Operations Research departments of universities. Additionally, the ability to explain the concepts in an efficient, intuitive way is not given to all the mathematical experts. We believe that this "knowledge gap," between expertise and explanatory ability needs to be closed, through co-operative research between learning institutions and airlines.

There are large imperfections in any valuation method, but we suggest that in managing large risks in investment decisions, an imperfect answer to management and shareholders is better than no answer.

## 11. Conclusion

We propose in this paper the notion that the NPV technique offers the potential for flexibility beyond its classic interpretation. Our proposed extension of Adjusted Present Value (APV) provides insight into lease vs. purchase decisions unavailable through classic NPV analysis. Equity NPV demonstrates the overall returns of the project from a shareholder perspective.

In order to benefit from these techniques, managers need very clear definitions of the elements of analysis – costs of debt and equity, cash-flow categories – in order to exploit the potential of the method.

APV is very useful in today's environment, as it measures the *cost* of flexibility in a concrete and consistent way. Real Options Analysis complements this analysis, by measuring the potential *value* of options. Practitioner can reason in terms of uncertain outcomes, in addition to measuring financial costs, yielding a complete picture of the investment dynamics.

The methods – in particular ROA - require further research and elucidation before they will be widely applied in practice. Financial theoreticians must also keep in mind that financial evaluation is only part of the extraordinarily complex evaluation of today's aircraft by airlines around the world.

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**Figure captions**

Figure 1 – Purchase vs. lease cash flows

Figure 2 – Adjusted Present Value and Net Present Value

Figure 3 – Distribution of fuel prices, 1990-2002

Figure 4: Binomial lattice representing potential project outcomes

Figure 5: Example of A320 purchase option lattice

Figure 1 – Purchase vs. lease cash flows

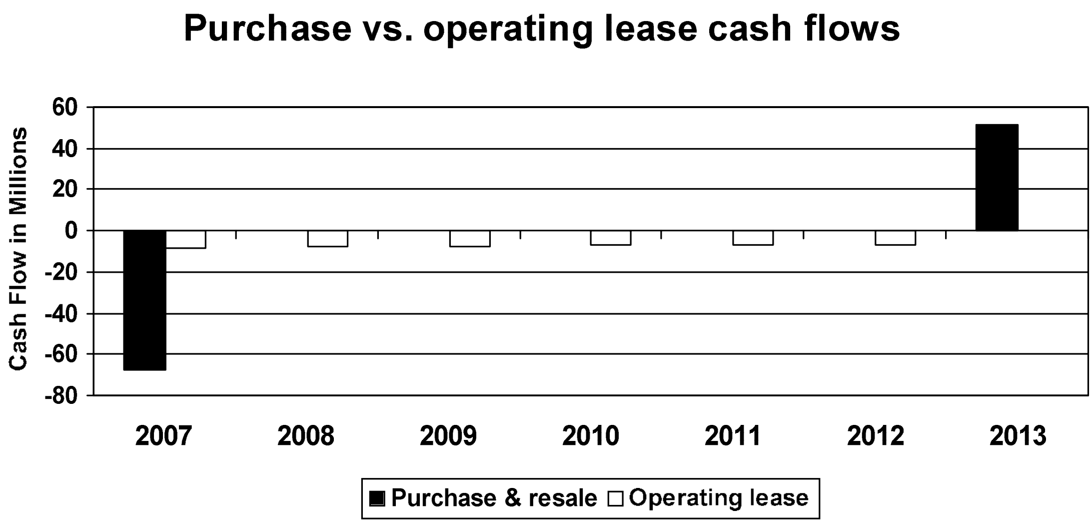


Figure 2 – Adjusted Present Value and Net Present Value

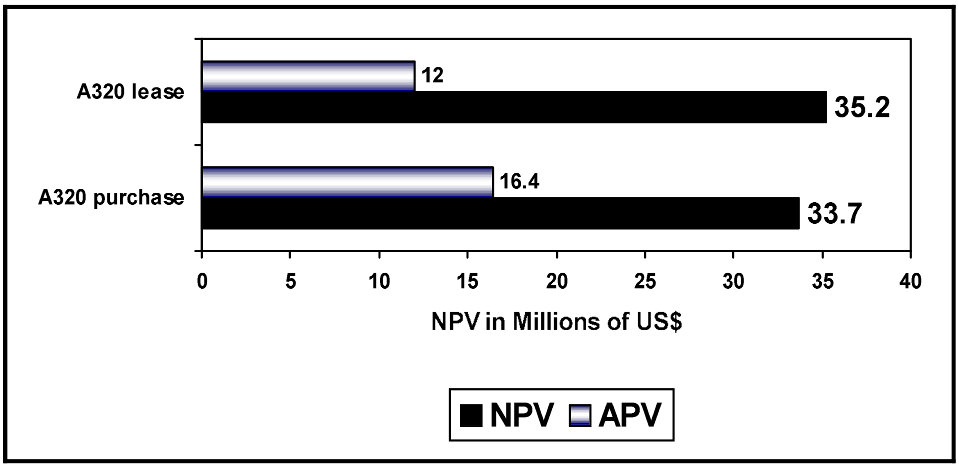

Figure 3 – Distribution of fuel prices, 1990-2002

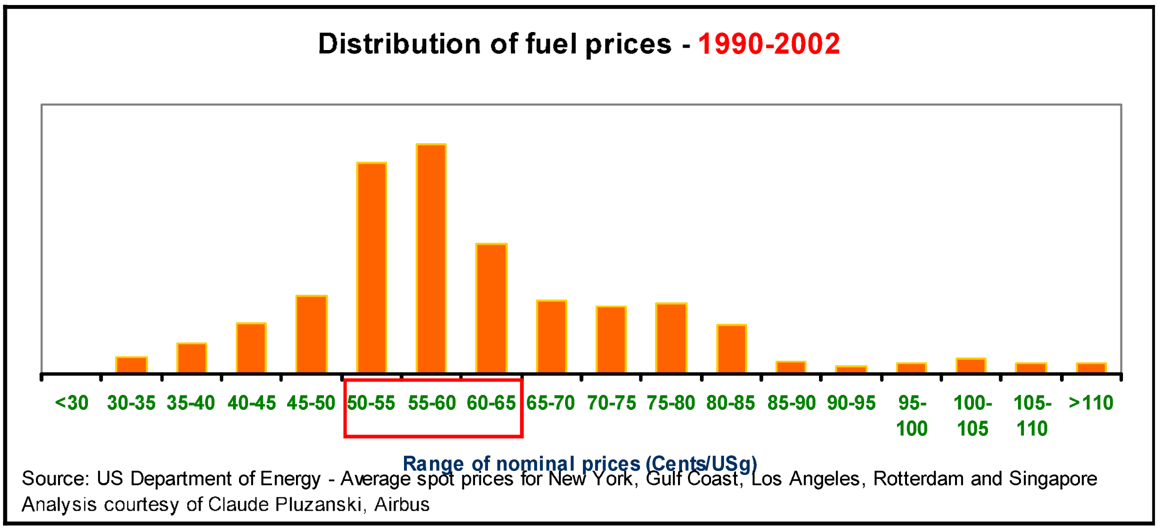


Figure 4: Binomial lattice representing potential project outcomes

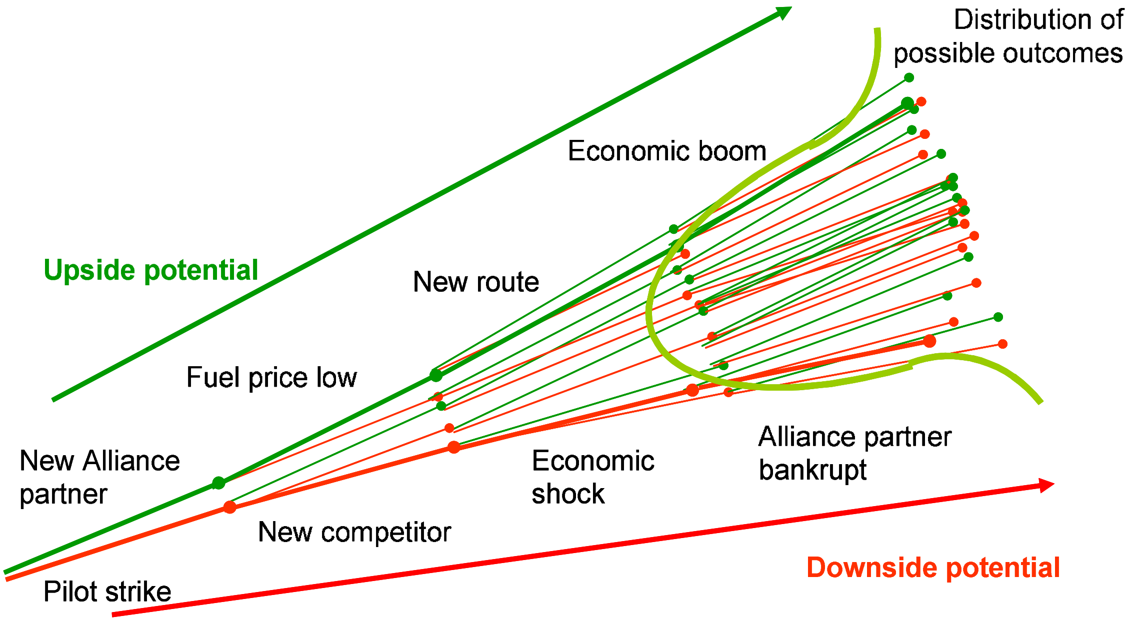


Figure 5: Example of A320-A321 conversion option lattice

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|---|---|---|---|---|---|
| A320 | A321 | A321 | A321 | A321 | A321 |
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| | | A320 | A320 | A320 | A321 |
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