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Real option analysis of aircraft acquisition: A case study

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ABSTRACT

This paper demonstrates that aircraft acquisition by airlines may contain a portfolio of real options (flexible strategies) embedded in the investment's life cycle, and that if airlines rely solely on the static NPV method, they are likely to underestimate the true investment value. Two real options are investigated: i) the "shutdown-restart" option (a carrier may shutdown a plane if revenues are less than costs, but restarts it if revenues are more than costs), and ii) the option to defer aircraft delivery. We quantify the values of these options in a case study of a major U.S. airline. The economic insight could help explain observed capital expenditures of airlines, and serve as a rule of thumb in evaluating capital budgeting decisions. A compound option (consisting of both the shutdown-restart and defer options) is also analyzed.

1. Introduction

The airline industry operates in a dynamic environment with a great number of uncertainties, with airline revenues and costs being influenced heavily by overall economic activities. How to evaluate investment projects in circumstances of uncertainty thus becomes crucial for airlines. Gibson and Morrell (2005) find that airlines predominantly use the static NPV (net present value) method[1] as their capital budgeting tools. The static NPV method is based on the traditional discount cash flow (DCF) approach, which has an implicit assumption that the investment will, once undertaken, be operated until the end of its useful life set at the very beginning. Under the predetermined scenario, cash flows are estimated based on predicted future revenues, costs, follow-up investments, etc., regardless of the changing circumstances in the future and likely managerial responses to some realized uncertainty outcomes. The DCF methodology thus implies a rigid managerial strategy that may not reflect real business decision-making of most firms, particularly those operating in a multiple risk environment like airlines. To survive in the dynamic environment, airlines' business strategy must be more flexible.

Real options analysis, on the other hand, combines the inherent uncertainty in the business environment with "managerial flexibilities", that is, firms would, in practice, adopt appropriate strategies from the options presented to them as time progresses and conditions change. In other words, firms are likely to actively alter their business strategies (e.g., expand or contract production scale, shutdown and restart a project, and defer or abandon the investment) in response to changing circumstances and new information. Such managerial flexibilities provide the management opportunities not only to minimize risk exposure and reduce losses, but also to capture profit potentials. In general, real option analysis provides more appropriate project evaluation than would the DCF method.

This article examines how airlines can correctly evaluate aircraft investment by comparing the static NPV (traditional DCF) method with real option valuation (ROV).[2] We demonstrate that aircraft

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[1] Gibson and Morrell (2005) survey the investment criteria, such as NPV, used by airlines, and report data on actual discount rates used at airlines. In particular, they find that airlines prefer the NPV method to the ARR (accounting rate of return) method. The reason is that while cash-based NPV techniques take the time value of money into consideration, ARR does not. They conclude, nevertheless, that finance departments of airlines do not necessarily capitalize on all useful methods available. For an empirical (field) study on the preference of capital budgeting tools of companies in a wide range of sectors, see Graham and Harvey (2001).

[2] Since the present paper is concerned primarily with the ROV process we shall, in the remainder of the paper, use ROV for "real option valuation" or, in some contexts for "real option analysis" (which may be abbreviated as ROA; but as pointed out by an anonymous referee, such an abbreviation could be misleading since ROA is closely associated with "return on assets" in the context of valuation).

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acquisition may contain a portfolio of real options embedded in the investment's life cycle. If airlines rely solely on static NPV analysis, they would underestimate the true investment value. Two basic real options are investigated: i) the "shutdown-restart" option, that is, a carrier shutdowns an airplane if revenues are less than costs, but restarts the plane if revenues are more than costs; and ii) the option to defer aircraft delivery (the defer option). We quantify the values of these options in a case study of a major U.S. airline. The economic insight could help explain observed capital expenditures of airlines and serve as a rule of thumb in evaluating capital budgeting decisions. We further examine a compound option that combines the shutdown-restart and defer options. The analysis shows that the value of the defer option depends on whether the option is considered as an independent option or as a part of the compound option.

Real option analysis has been used in the valuation of large transportation capital acquisitions such as aircraft and containerships. Stonier (1999, 2001a, 2001b) applies the pricing model of binomial tree to evaluate the aircraft option, and obtain a set of potential expected NPVs under Monte Carlo simulation. Gibson and Morrell (2004) apply the same model to value an aircraft family conversion option. Bendall (2002) and Bendall and Stent (2003, 2005, 2007) examine, in the container shipping industry, values of the option to expand or contract operations and the option to switch the introduction mode (build or charter a ship) in the usual fashion of bivariate geometric Brownian motions. For example, Bendall and Stent (2005) find that shipping companies value flexibility when making ship acquisition decisions under uncertainty. Following a similar ROV, the present paper complements the existing literature that utilizes mainly the Monte Carlo simulation and closed-form equations approaches. We explore a binomial-tree model in which the NPV of aircraft acquisition is used as the value of underlying asset. Furthermore, the paper examines a compound option with the shutdown-restart and defer options as its components. We note that such a compound option has yet been analyzed in the airline literature.[3]

Our paper also complements the extant literature investigating the question of whether airlines invest in aircraft capacity efficiently or not. For instance, Wojahn (2012) examines the causes for the well-documented phenomenon of capacity over-investment in the airline industry based on a data set covering all publicly listed airlines. He finds that agency problems (e.g., myopia and empire building) and the shift toward low-cost and Asian carriers coupled with remnants of capital in legacy airlines, as well as economies of scale, are all associated with over-investment. An important feature that is not investigated in his paper is the oligopoly rivalry examined by, e.g., Brander and Lewis (1986) and Oum et al. (2000a): i.e., with the limited-liability effect investment with debt financing serves as a "top dog" strategy in airline output rivalry, leading to over-investment in capacity. Our analysis quantifies the option values that appear to have been ignored by airlines in their aircraft investment decisions with the use of DCF method. On the other hand, in practice airlines do seem to exercise these options by adjusting their flight schedules and overall capacity with the changes of business environment. Taken together, our results, while seemingly being in the opposite direction of explaining the observed over-investment anomaly, suggest that the anomaly may be more pronounced than was thought previously.[4]

The paper is organized as follows. Section 2 discusses key issues in ROV and aircraft investment valuation. Section 3 sets out decision scenarios of the case study. Section 4 conducts ROV for the case and presents the main results, which are then followed by a sensitivity analysis in Section 5. Finally, Section 6 contains concluding remarks.

2. Real option analysis in aircraft investment

2.1. Valuing real options

The central insight of ROV is that a (potential) project should be valued fully by including options embedded in the project, which can be viewed as managing a portfolio of options (Luchrman, 2001). Some options are taken simultaneously while others sequentially. When moving along with the project, managers can implement strategies that are adaptable to the revelation of uncertainties. Further, project options (strategies) are asymmetric in nature, in the sense that management can reduce losses and maximize gains by intervening at the right time (Yao and Jaafari, 2003). Thus the static NPV approach is more suitable for a project that, once undertaken, requires no further decisions or actions by management. The project value will rise if real options exist, however.

ROV is related to the important advancement in the research on financial-option pricing in the 1970s. Black and Scholes (1973) and Merton (1973) developed the quantitative methodology of pricing financial options. The Black-Scholes model, however, is "complex and off-putting to many practitioners" (Cox and Ross, 1976). Cox et al. (1979)'s binomial approach presented a simplified valuation of financial options in discrete time. Cox and Ross (1976) recognized that an option can be replicated (to create a "synthetic" option) from an equivalent portfolio of traded securities, and facilitated further the actual valuation of options.[5]

Mason and Merton (1985) and Kasanen and Trigeorgis (1993) maintain that real options can in principle be valued in a manner similar to financial options, even though they may not be traded as are the financial options. This is because the course of capital budgeting determines the value of the project's cash flows in the market. The replicating portfolio approach is based on the "law of one price:" that is, to prevent arbitrage (riskless) profits, two assets with the same risk characteristics ("twin securities") in every state of nature are perfectly correlated with the underlying risky asset and, therefore, the non-traded real asset in complete market is sufficient for real-option valuation. Copeland and Antikarov (2001) suggest that, since finding a market-based twin security that is perfectly correlated with the underlying asset would be difficult, the NPV of the project itself be used as the value of underlying asset (rather than searching for a perfectly correlated asset in the market). It is this approach that will be taken in this paper. The full value of a project is thus the sum of the static (inflexible) NPV and the value for managerial flexibilities (real options):

[3] More generally, the early ROV literature focused on the theoretical issues or valuation of a specific real option, such as the options to defer or abandon or to switch use, in a wide range of fields (natural resource, real estate, research and development, etc.). This one-at-a time approach can be limited however, as the combined value of a collection of operating options may differ significantly from the sum of separate option values (e.g., Cox et al., 1979; Schwartz and Trigeorgis, 2001; Trigeorgis, 2001).

[4] That is, the results may in effect provide some support to the hypothesis that airlines overestimate values of the shutdown-restart option and other options. The paper is also related to a branch of literature on aircraft investment concerning the choice between ownership and lease (e.g., Gritta et al., 1994; Littlejohns and McGairl, 1998; Oum et al., 2000b; 2000c; Gibson and Morrell, 2004; Allonen, 2013). Gibson and Morrell (2004) indicated that 25% of airlines' aircraft are leased, of which about 80% are operating leases (Gritta et al., 1994). A very useful general reference on airline finance is Morrell (2007).

[5] See Gibson and Morrell (2004) who introduce NPV, stochastic NPV and real-options approaches to aircraft financial evaluation.