The true value of a capital investment is linked to the future decisions of management about such issues as competition, expansion and operational processes, but how are these issues valued?

RICHARD MARRIOTT explains the role of contingent claims analysis.

Finance academics have for many years been champions of net present value (NPV) as the most appropriate method for capital budgeting analysis and valuation. On a broader front, empirical work suggests that NPV is widely used in business even though the underlying concepts may not be fully understood. In addition, the internal rate of return (IRR) remains prominent despite its well known weaknesses.

However, since the early 1980s a growing number of academics and practitioners have agreed that NPV and IRR do not fully value capital investment opportunities, pointing out that NPV does not incorporate future decisions that management might make.

The difficulty that this can cause can be summarised by the example of an investment opportunity where the quantitative analysts of the organisation produce a negative or neutral NPV, while the senior management and board of directors believe that the investment must be made for strategic reasons.

Typically some polarisation develops between the strategists who look at the project from the viewpoint of what it will accomplish, and the quantitative analysts whose viewpoint is directed to what the project will cost. The result can be stalemate, division, and lack of effective decision-making.

This concern has been addressed through the development of a relatively new branch of financial theory which is often referred to as contingent claims analysis (CCA) but is simply the application of option pricing theory (OPT) in capital budgeting. For a number of reasons, the application of OPT to capital assets is generally considerably more complex than its application to financial assets.

At the current stage of the development of CCA, it is usually only cost-beneficial to undertake a complete analysis for large, risky, long-lived investments such as infrastructure and natural resource projects. Much of the early work (in the late 1970s and early 1980s) was on such projects as the Alaska gas pipeline and the mining of tar sand deposits in Canada. Such analysis requires computer modelling and the numerical solution of partial differential equations.

However, much insight into the more common capital investment decision process can be gained by understanding the broad thrust of CCA. Rough estimates of "strategic" value can be derived by using simpler valuation models such as the Black-Scholes model or the Binomial model, as long as the practitioner does not lose sight of the simplifications and assumptions underlying these methods.

The advantage of CCA is that it allows the quantitative versus qualitative stalemate between analysts and strategists to be tackled in a rational way that is consistent with NPV and can provide a framework on which the strategists can build their future decisions.

TYPICAL APPLICATIONS

As illustrations of the potential application of the CCA approach, the following are typical project values that are not readily captured by traditional NPV methodology:

- The management of an electricity
generating facility has a choice between building a coal-fired plant, or one that can use both coal and oil. The second option costs more to build but introduces operational flexibility so that management can take advantage of any change in relative prices between coal and oil. This certainly has an economic value and should be considered as part of the overall investment decision.

- Oil refineries and chemical plants which can produce the same output from a variety of inputs, or a variety of outputs from the same inputs, demonstrate a significant level of operational flexibility in the sense of providing extensive management decision opportunities in the future.
- A plant to be built may not operate continuously because of extreme price fluctuations on the output side. It may be economical to shut down operations for periods when revenue is not expected to cover fixed costs. At the extreme the plant could be closed permanently (abandoned). Such flexibility can be captured by application of CCA principles.
- Management may choose to build a plant which makes it relatively easy to expand or contract output, even if it is more costly to build initially. Similarly, management may choose to build a plant with a longer life than currently thought desirable, so as to have the option of continuing in production if demand is higher than expected.

One way of implementing these choices is to build plant with relatively low capital cost but higher maintenance costs. The life and productive output of the plant can then be a function of the amount spent on maintenance and therefore add significant future flexibility to the project.
- The timing of the start of a project may be a source of considerable value. Delay allows more information to become available, and may therefore reduce risk. Delay might also allow competitors into the market so the choice under consideration must, to at least some extent, be proprietary. Typical examples of the value of delay are found in the resource sector, where mining loans are held over proven deposits but the current commodity price may not cover extraction costs.
- Perhaps one of the most powerful applications of CCA is in the valuation of sequential investments, where a decision is to be made at each stage about whether to proceed to the next stage. Clearly, NPV does not capture the full value of such an opportunity because it implicitly assumes that each stage will take place or, alternatively, looks at each stage as a "stand-alone" project.

NPV partially captures the effects of sequencing decisions by assigning some probability to the likelihood of each step actually going ahead, but this must all be valued using information available today.

An example of sequencing is a decision on research and development, successful completion of which will lead to prototyping, pilot plants, and full-scale production. R&D on its own will certainly be all cost and no revenue, but it paves the way for potentially profitable future investments.
- A different set of options are those that management implements to "protect" a current project or market position. An example is the takeover of a competitor even if the analysis shows the takeover is NPV-negative. Once the takeover is complete, the current product line can continue to make large returns without undue market competition. It has been suggested that many mergers and takeovers proceed despite marginal NPV analysis because of either "protection" or "expansion" options.
- The above examples relate to options regarding physical assets – the "investment" decision of capital budgeting. However, the "financing" aspects of capital budgeting can also be a source of considerable flexibility, including possibilities such as the ranking of debt facilities (senior, junior etc), guarantees, underwritings and insurances. In addition specialised forms of financing securities, such as warrants or convertible bonds, also provide financial flexibility. To the extent that this flexibility can be incorporated into the capital budgeting process it has a real economic value that is not captured by traditional NPV methodologies.

**IMPORTANT OF OPTION IDENTIFICATION**

While any single operating option might not itself be important, the combined effect of several options may be substantial. Neglecting, or failing to identify, the major operating options embedded in an investment opportunity may significantly undervalue the project and may even lead to rejection.

Of course, not all opportunities have significant operating options attached to them and it is tempting to adjourn the analysis after NPV has been established. However, such an approach could actually overvalue the project by failing to recognise the loss of flexibility built into the project as currently contemplated.

It follows that the valuation of any project should include at least an initial identification of the operating options that are attached (or could be attached), and a decision about which, if any, may be sufficiently significant to justify the costs of valuing them.
Since we know that option value generally increases with the time between the present and exercise date, increases in the risk-free rate, and increases in volatility of the underlying project cashflows, the most likely projects to gain significantly from the application of these valuation techniques are those of long-life and highly variable cashflow generation. If interest-rate movements are likely to be significant, then this also lends weight to the argument that CCA should be applied.

**ALTERNATIVE QUANTITATIVE APPROACHES**

Three other techniques have been used in the analysis of complex capital budgeting:

- Monte Carlo simulation;
- decision trees; and
- modified discounted cashflow.

**Monte Carlo simulation**

This requires the formulation of a model that incorporates all the relevant variables and the relationships between them. Each variable is considered to be random and therefore able to take on a range of values. Monte Carlo simulation requires the selection, at random, of a value for every variable in the model and then the output of the model is calculated. The process is repeated many times (from hundreds to thousands) until a defined distribution of possible outcomes is achieved. Typically the distribution of outcomes will show a tendency towards a central value of output and with outcomes of lower probability tapering off on either side.

The principal difficulty of Monte Carlo simulation is that the output distribution does not easily translate into a decision. The eventual decision depends critically on who has the responsibility of interpreting the output distribution.

**Decision trees**

Most mainstream finance texts contain a section on the use of decision trees in capital budgeting. The technique is useful to the extent that it allows the explicit modelling of future decision-making. However, it also relies on the allocation of specific probabilities to the various decisions being made, and is hampered by ambiguity in the selection of a discount rate. Even a project of modest scale can result in a decision-tree model so large that it is difficult to fully comprehend.

**Modified discount rate**

Based on portfolio theory, some firms arbitrarily assign a cost of capital (hurdle rate) to different “strategic” classes of investment (eg, “grow business”, “maintain current business”, “harvest business”). Normal application of NPV then produces the correct decision-making answer. Despite the appearance of rigour with adjusted hurdle rates it actually produces the worst of both worlds: the true present value is not calculated, while the opportunity for management to exercise judgment and experience is diminished.

The CCA approach has the advantage over these alternatives that, no matter how complex the project, the resulting evaluation is internally consistent with the basis of equilibrium pricing in financial markets. That is to say, CCA is firmly bound into the body of current financial theory in a way that none of the alternative methods are.

For this reason CCA is particularly suited for use as a planning tool because it can be used to examine a large number of scenarios with the comforting knowledge that any unexpected results are not likely to be caused or explained by deficiencies in the model itself.

**HOW VALUABLE ARE OPERATING OPTIONS?**

Option pricing theory, when applied to financial assets, states that a call option is never worth less than the current price of the underlying stock less the exercise price, and may be worth a lot more. For example, a call option on BHP stock (trading at $12), with an exercise price of $10, must be worth at least $2 and probably more.

Similarly, when applied to capital budgeting, the opportunity to undertake the project is worth at least the NPV and probably much more. The factors that will determine the additional value include the following.

**How long the final decision to proceed can be deferred**

The longer this period, the more likely it is that further useful information will become available and hence reduce the risk of a costly error. Even an opportunity with negative NPV may be worth holding as an option if there is some probability that something will happen to make the project more valuable.

**Project risk**

In traditional NPV analysis high risk is not a desirable feature unless matched by a suitably adjusted high return. In option pricing, high risk is a virtue because of the asymmetric payoffs from exercising the option. The downside is protected while the upside is uncapped. Thus, the more variability in the project outcomes, the more likelihood there is of having a strong upside, while the downside risk is unchanged.
The level of interest rates
Usually we think of high interest rates in terms of how this raises the discount rate for NPV and hence reduces the present value of the expected cashflows. However, with options, the present value of the future exercise price is important, so that the higher interest rates imply that a smaller amount of capital needs to be set aside today to meet the exercise price in the future. Thus the value of the option actually rises as interest rates rise.

Exclusivity of the option
Figure 1 combines the extent to which the option is proprietary (a single firm has the opportunity to exercise it) and the timeliness of the need to exercise (the diagram is based on Kester [1984]).

Proprietary options are highly valuable and usually derive from patents, monopoly power, or other advantages that competitors cannot reasonably replicate. At the other end of the spectrum are shared options which might be available to a number of firms, an entire industry, or the whole economy. Such options are clearly less valuable since, if a firm exercises an option, competitors can undertake a counter-investment that can erode or preempt expected profits.

Shared options are generally most useful to a firm in a dominant position in the market so that the firm can resist attempts by other firms to capture some of the value flowing from the option.

In Figure 1 a firm in the top right or bottom left quadrants will have clear directions on what to do with the options available but the other quadrants are less clear. For example a firm may exercise a proprietary option early if the industry is very competitive and an early commitment to the new project is likely to discourage competition.

A FRAMEWORK FOR IDENTIFYING OPTIONS
Kester (1984) points out that no single formula will apply in every case of embedded option analysis and therefore the first step in option identification might best be qualitative, although rooted in the theory of option valuation.

For this approach, the classical differentiation between capital investment classes (replacement, cost reduction, expansion, new product introduction etc) is not appropriate. Instead, the projects should be classified according to those whose future benefits are realised primarily through cashflows (simple options) and those whose future benefits include opportunities for further discretionary investment (compound options).

Simple options generally require only NPV valuation but compound options, because of their complexity and their role in shaping a company's strategy, demand a broader analysis. Given the overall company strategy, the management should choose the combination of options that brings the right investment opportunities to the market at the right time. The company should separate those projects that require an immediate go/stop decision, and those that can be safely deferred for later action. Lastly, projects should be classified as being proprietary or shared.

In summary, a simple, immediate-investment, proprietary option should be valued by standard NPV. Any other combination will possibly benefit from a CCA approach.

REFERENCE