The real power of **real options**

Keith J. Leslie and Max P. Michaels

Change the way you create value: The case for applying options thinking to any strategic situation.

Over 30 years of operation, one North Sea oil company accumulated a portfolio of license blocks—five-year rights to explore and produce oil and gas. Where net-present-value (NPV) analysis suggested that the economics were positive, the company drilled and developed the blocks. Where the blocks proved uneconomic—as most did, usually because development costs were too high in relation to expected revenues—development was shelved. Left with unwanted blocks that were consuming cash (albeit very little) and that had limited investment appeal, the company decided to sell them to other companies that would buy them, cheaply, for reasons of geography or strategic fit.

At one point in the divestment program, it was suggested to the company's managers that, instead of calculating what the blocks would be worth if the company started developing them immediately, it should value its opportunity as an option to develop if, at some point in the future, recoverable

Keith Leslie is a principal in McKinsey's London office, and **Max Michaels** is an alumnus of the New York office. This article was originally published in *The McKinsey Quarterly*, 1997 Number 3.

This article can be found on our Web site at www.mckinseyquarterly.com/corpfina/repo97.asp.

reserves could be increased through the use of new drilling and production technologies. In other words, the managers should apply the notion of options, as conceived in financial markets, to their own business situation.

A simple financial model showed the company's managers how to price blocks at their option value over five years, incorporating uncertainty about the size of the reserve and oil prices and leaving room for a flexible response to the outcome. The managers reevaluated the company's portfolio, and instead of letting blocks go for a notional amount, they decided to hold on to those with high option value and to sell or trade the rest at their revised worth.

This case builds on the model developed for financial options by Fischer Black and Myron Scholes as modified by Robert Merton,[1] and specifically on the observation by Stewart Myers of the Massachusetts Institute of Technology that Black-Scholes could be used to value investment opportunities in real markets—the markets for products and services.[2] The value of keeping one's options open is clearest in investment-intensive industries, such as oil extraction, in which the licensing, exploration, appraisal, and development processes fall naturally into stages, each pursued or abandoned according to the results of the previous stage. Indeed, our work in the energy sector reveals that a number of excellent performers do instinctively or intuitively view their investment opportunities as real options, positioning themselves to tap possible future cash flows without making a final decision to invest until the potential is confirmed. But companies in every type of industry have to allocate resources to competing opportunities; whether in existing businesses or new ventures, they have to decide whether to invest now, to take preliminary steps reserving the right to invest in the future, or to do nothing. Because each of these choices creates a set of payoffs linked to further choices down the line, all management decisions can be thought of in terms of options. So why is it that real options—despite their apparent relevance in business decisions and the fact that they are attracting growing support in academia—have not been recognized or applied by other companies, particularly in industries characterized by high levels of R&D, manufacturing, and marketing investment?

The reason may be that options theory is notoriously arcane. To be sure, many discussions that go beyond the conceptual level get bogged down in the mathematics of Black-Scholes valuation. However, we believe that, just

[1] Myron Scholes and Robert Merton were awarded the 1997 Nobel Prize in economics for their financial-options valuation model. Fischer Black, who died in 1995, was mentioned in the award citation.

[2] "The pricing of options and corporate liabilities," *Journal of Political Economy*, 1973, Volume 81, Number 3, pp. 637–54.

as many investments are made by managers who have only a passing acquaintance with the capital-asset pricing model or the subtleties of estimating the cost of capital and terminal values for NPV calculations, so the fundamental insights of real-options theory can be used, successfully, by managers who have no more than a basic understanding of option-pricing models.

Thinking in terms of real options

There is another compelling reason for managers to grasp the insights behind real options. While option-pricing models are indeed a superior valuation tool—the usual use of the theory—we believe that real options can also provide a systematic framework serving as a strategic tool and that the real power of real options lies in this strategic application. This article seeks to provide such a framework.

The six levers of financial and real options

The price of a financial option is typically estimated by the application of the Black-Scholes formula[3]:

$$\mathbf{S e^{-\delta t} * \{N(d_1)\} - X e^{-rt} * \{N(d_2)\},}$$
$$\textbf{where } \mathbf{d_1 = \{\ln(S/X) + (r-\delta+\sigma^2/2)t\}/\sigma * \sqrt{t},}$$
$$\mathbf{d_2 = d_1 - \sigma * \sqrt{t},}$$

and where S = stock price, X = exercise price, δ = dividends, r = risk-free interest rate, σ = uncertainty, t = time to expiry, and $N(d)$ = cumulative normal distribution function.[4] The real-market equivalents of these factors are as follows:

Stock price *(S)*: the present value of cash flows expected from the investment opportunity on which the option is purchased.

Exercise price *(X)*: the present value of all the fixed costs expected over the lifetime of the investment opportunity.

Uncertainty (σ): the unpredictability of future cash flows related to the asset; more precisely, the standard deviation of the growth rate of the value of future cash inflows associated with it.

[3]The original formula calculates the theoretical option value—the present value of the expected option payoff—under the assumption of no dividend payments, taxes, or transaction costs. As modified by Robert Merton, the formula incorporates dividends (δ): it reduces the value of the share to the option holder by the present value of the forgone dividend and reduces the cost of holding a share by the dividend stream that would be received.

[4]$N(d_1)$ = the proportion of shares required to replicate the call option and $N(d_2)$ = the probability that the call option will be exercised on expiry.

Time to expiry *(t)*: the period for which the investment opportunity is valid. This will depend on technology (a product's life cycle), competitive advantage (intensity of competition), and contracts (patents, leases, licenses).

Dividends *(δ)*: the value that drains away over the duration of the option. This could be the cost incurred to preserve the option (by staving off competition or keeping the opportunity alive), or the cash flows lost to competitors that invest in an opportunity, depriving later entrants of cash flows.

Risk-free interest rate *(r)*: the yield of a riskless security with the same maturity as the duration of the option.

Increases in stock price, uncertainty, time to expiry, and risk-free interest rate raise the option value. Increases in exercise price and dividends reduce it (Exhibit 1).

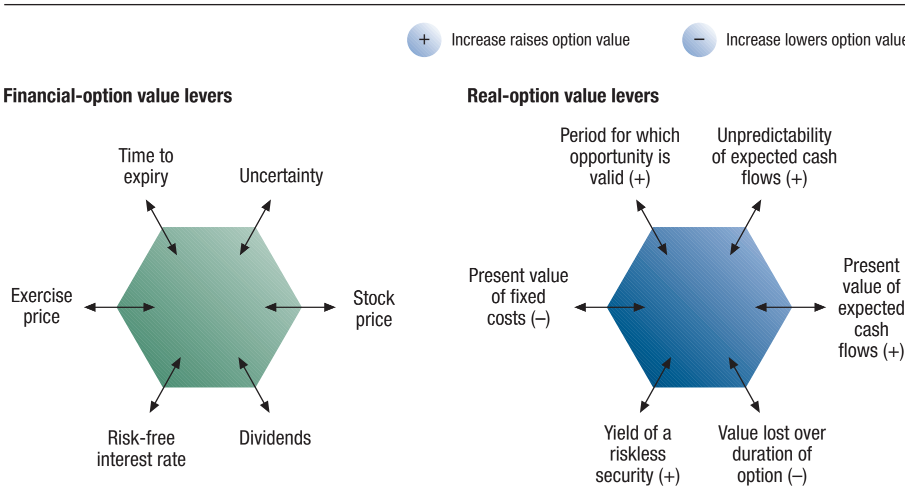
Why real options are important

Because traditional valuation tools such as NPV ignore the value of flexibility, real options are important in strategic and financial analysis. Consider the example of another oil company, which has the opportunity to acquire a five-year license on a block. When developed, the block is expected to yield 50 million barrels of oil. The current price of a barrel of oil from this field is, say, $10, and the present value of the development cost is $600 million. Thus the NPV of the opportunity is simply:

$500 million – $600 million = –$100 million.

EXHIBIT 1

The six levers of financial and real options



Faced with this valuation, the company would obviously pass up the opportunity.

But what would option valuation make of the same case? Such a valuation would recognize the importance of uncertainty. There are two major sources of uncertainty affecting the value of the block: the quantity and the price of the oil. The company can make a reasonable estimate of the quantity of the oil by analyzing historical exploration data in geologically similar areas. Similarly, historical data on the variability of oil prices are readily available. Assume for the sake of argument that these two sources of uncertainty jointly result in a 30 percent standard deviation (σ) around the growth rate of the value of operating cash inflows. Holding the option also obliges the company to incur the annual fixed costs of keeping the reserve active—let us say, $15 million. This represents a dividend-like payout of 3 percent (that is, 15/500) of the value of the asset. We already know that the duration of the option, t, is five years and that the risk-free interest rate, r, is 5 percent, leading us to estimate option value at

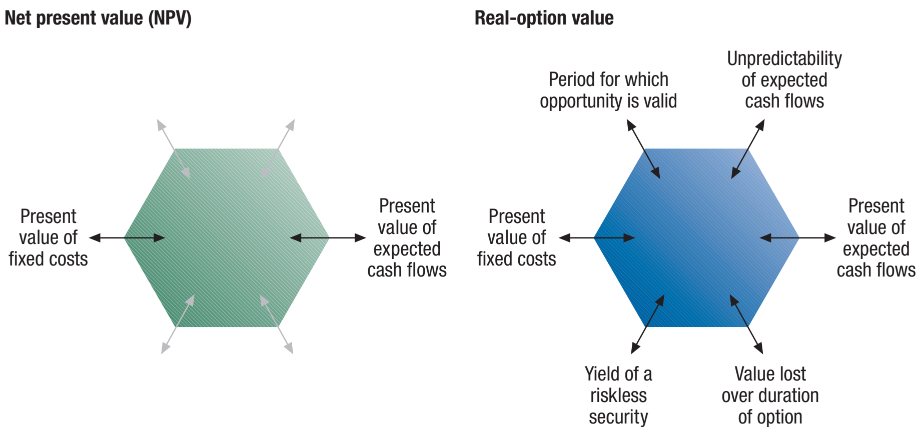
$$\mathbf{ROV} = (500e^{-0.03*5})*\{(0.58)\} - (600e^{-0.05*5})*\{(0.32)\}$$
$$= \$251 \text{ million} - \$151 \text{ million} = +\$100 \text{ million.}$$

Where does this $200 million difference come from? Consider a simple financial option, available at $17 for an exercise price of $70 when the stock is trading at $83. A buyer who exercised the option immediately would have a payoff of $13 but would be $4 out of pocket, having paid $17 for the option. The $4 represents the value of the flexibility inherent in not having to decide whether to make the full investment immediately, a flexibility whose value an NPV analysis would recognize as zero. So too in this case: the $200 million is the equivalent of the $4.

Ultimately, then, the option valuation recognizes the value of learning. This is important because strategic decisions are rarely one-time events, particularly in investment-intensive industrial sectors. NPV, which relies on all-or-nothing, "go/no go" decisions and doesn't properly recognize the value of learning more before a full commitment is made, is for that reason often inadequate. In fact, NPV's inadequacy can be stated in the precise terms of the real-options model. Of the six variables in that model, NPV analysis recognizes only two: the present value of expected cash flows and the present value of fixed costs. Option valuation offers greater comprehensiveness, capturing NPV plus the value of flexibility—that is, the expected value of the change in NPV over the option's life (Exhibit 2, on the next page).

EXHIBIT 2

Comparison of valuation methodologies



Leveraging flexibility: Influencing the value of real options

Some kinds of flexibility are obviously common to financial and real options. In each case, an option holder can decide whether to make the investment and realize the payoff, and if so, when to invest—important, since the payoff will be optimal at a particular moment. These are essentially reactive kinds of flexibility: an option holder responds to environmental conditions to maximize the payoff.

When we talk about the reactive flexibility of a real option, however, we are ultimately talking only about its advantages as a valuation tool. The further, and typically larger, payoff comes from the proactive flexibility to increase the value of an option, once acquired. This opportunity arises from the fact that, while a financial option is acquired and exercised in a deep and transparent market, real business situations usually feature a limited number of players—each able to influence a few specific levers that control the value of real options—interacting with one another. Thus, managers can use their skills to improve an option's value before they actually exercise the option, making it worth more than the price paid to acquire or create it.

Lever 1: Increase the present value of expected operating cash inflows. This is achieved as a result of increasing revenues by raising the price earned or producing more of the commodity in question or by generating sequential business opportunities (creating, in effect, what is usually called a "compound option").

Lever 2: Reduce the present value of expected operating cash outflows. There are two basic ways to cut costs: leveraging economies of scale (the cost per unit falls as the number of units rises) or leveraging economies of scope (using the same costs to do two different things). A company unable to do these things alone could perhaps do so in partnership.

Lever 3: Increase the uncertainty of expected cash flows. Greater uncertainty raises the value of an option by increasing the value of flexibility. This is perhaps the crucial difference between options and NPV analysis. When a company is fully invested, as NPV analysis assumes, uncertainty has a negative effect because returns are symmetrical; that is, losing one's entire investment is as much a possibility as doubling its value. But in buying an option, a company hasn't bet the entire value of its investment: it is exposed to the upside but not the downside. As a consequence, an option holder wants to do everything it can to increase the uncertainty of expected returns and then exercise at the top or back out, depending on how things go. This is an important point that has a number of counterintuitive implications, as the following example shows.

North Sea gas companies have typically created value by building early competitive positions and quickly exploiting their license blocks. A few, however, have pursued an options strategy based on the fact that, unlike markets for oil, natural-gas markets are usually local and opaque because of the difficulty of storing and transporting gas. These companies actively encourage competitive entry into a geological area and defer their investments until competitive activity has picked up. The greater the uncertainty over future investment (and therefore production) plans, the greater the price volatility, the greater the incentive for gas buyers to commit themselves to high-priced supply—and thus the greater the option value of a license block. Companies must weigh the value created by waiting, on the one hand, against the value lost through a delay in developing the license blocks and subsequent delays in the supply of gas, on the other. Using a real-option strategy provides two benefits. First, these companies leverage their reactive flexibility to make more informed investment decisions based on new information from competitive activity. Second, they leverage their proactive flexibility to secure better prices from customers nervous about uncertainty over the supply of gas.

Lever 4: Extend the opportunity's duration. This raises an option's value because it increases total uncertainty.

Lever 5: Reduce the value lost by waiting to exercise. In financial options, this is the cost of waiting until after the payment of a dividend (which lowers the stock value and therefore the option payoff). In a real business situation, the cost of waiting would be high if an early entrant seized the initiative. When first-mover advantages are significant the dividends are correspondingly high, thus reducing the option value of waiting. The value lost to competitors can be reduced by discouraging them from exercising their options—for example, by locking up key customers or lobbying for regulatory constraints.

Lever 6: Increase the risk-free interest rate. This is not an issue in the discussion of proactive flexibility, because the risk-free rate cannot be influenced by any player. But it is worth noting that, in general, any expected increase in the interest rate raises the value of an option, despite the negative effect on NPV, because it reduces the present value of the exercise price.

Choosing your levers

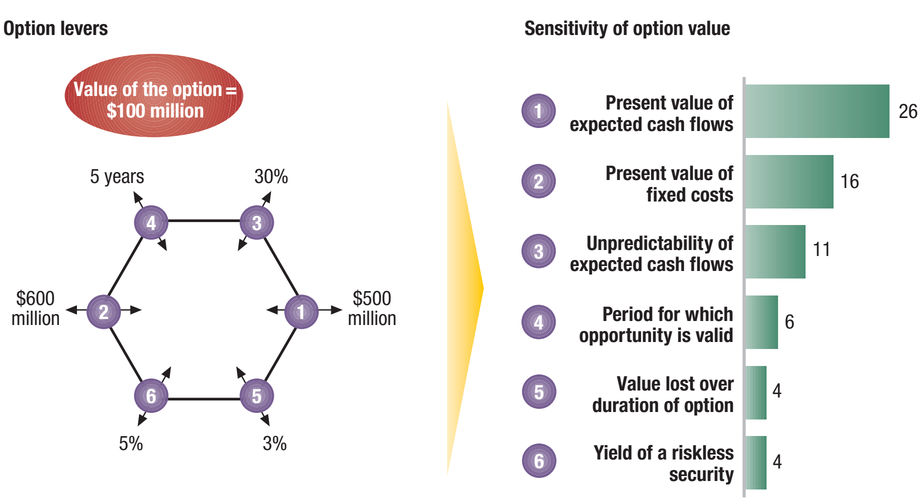
Which levers should a company pull? Which levers can it pull? The first question—one of economic priority—can be answered by a straightforward sensitivity analysis.

Take, once again, the example of the license blocks that real-option valuation judged to be worth $100 million and NPV analysis recognized as minus $100 million. If we assume a 10 percent increase in each lever, we see immediately that changes in the lease's duration, the risk-free interest rate, and the annual cost of the lease (or value lost over the duration of the option) have less effect than changes in the present value of expected cash inflows and cash outflows, as well as the level of uncertainty. A 10 percent improvement in each of these levers adds about 26 percent, 16 percent, and 11 percent, respectively, to the value of the option (Exhibit 3). So it appears to be better

EXHIBIT 3

Pulling the real-option levers

Change in option value resulting from a 10% change in each lever, percent



to focus on getting revenue up than on getting costs down—a key insight in option-value management. There are, of course, external constraints, such as competition or market regulation. But even if it should turn out that the more powerful levers are less easily influenced, the analysis reveals that improving duration and "dividend" (that is, annual costs) by 10 percent each can together yield a significant return.

> Making one-time decisions on the basis of static investment plans tends to **narrow the vision,** making it difficult to change course

The question of which levers can be pulled is simply one of the internal and external constraints on the operations of the company. These constraints might be technical, or they might have to do with marketing, negotiating, or contractor management issues. They would also concern investment factors such as the delay between investment and payoff, as well as constraints on incremental investment.

Changing the way management thinks

The final, and perhaps greatest, benefit of real-options thinking is precisely that—thinking. The very exercise of working through options systematically begins to change the way management thinks. Here again, the appropriate contrast is with NPV analyses, which typically assume a fixed, multiyear investment model against a fixed expectation of annual return. Making one-time decisions on the basis of static investment plans tends to narrow the vision, so that even when it is possible to change course or abandon a multiyear investment project, managers who may have submitted project forecasts for many years ahead find it difficult to do so.

Real-options strategies are distinguished from their traditional counterparts above all by their response to uncertainty. The shift in outlook from "fear uncertainty and minimize investment" to "seek gains from uncertainty and maximize learning" opens up a wider range of possible actions and is crucial to the usefulness of real options as a strategic rather than a valuation model (*see* sidebar, "Best practice in managing real options," on the next page). With hindsight, the resulting actions frequently seem obvious—but that is merely the mark of an effective model.

The discipline of applying real-options analysis to every investment possibility will improve a company's strategies in four ways:

Emphasizing opportunities. A real-options strategy emphasizes the logic of strategic opportunism, forcing managers to compare every incremental opportunity arising from their existing investments with the full range of opportunities open to them. Such an approach is especially important in mature industries, where managerial inertia often manifests itself as escalating commitment.

Enhancing leverage. Real-options strategies promote strategic leverage, encouraging managers to exploit situations in which incremental investment can keep their companies in the game. Multistage investment in the oil exploration, drilling, and production processes is highly leveraged, as exploratory investments represent only a fraction of the total. (This, however, is different from simultaneous investment in multiple opportunities, which reduces the upside as well as the downside. Thus, leverage distinguishes real-option strategies from traditional diversification strategies that reduce risk.)

Maximizing rights. Investors in oil-block licenses, for example, have the opportunity to develop certain fields and the right to all profits. The investment

Best practice in managing real options

BP, a UK company, exemplifies the benefits of real-options thinking. Between 1990 and 1996, BP increased its market value to $30 billion, from $18 billion, representing a total return to shareholders of 167 percent, in a mature industry and against a background of falling reservoir sizes and volatile oil and gas prices quite unlike the boom days of the 1970s and early 1980s. Pursuing a strategy of making incremental investments to secure the upside while insuring against the downside, the company delayed committing itself to investment until it had confirmed—usually by acting on the six levers of option value—that its money would be well spent.

As noted earlier, the sequence of spending decisions that leads to the development of an oil or gas field constitutes a classic real option. First, a company acquires a license to explore; then it engages in low-cost seismic exploration. If the results are promising, exploratory drilling is undertaken. If the exploratory well is positive, appraisal drilling takes place. Full development—and most expenditure—goes ahead only if these preliminary stages are completed satisfactorily.

Although correct, this description captures no more than the value of the real option's reactive flexibility. BP paid the penalty for taking a limited, reactive flexibility approach when it developed the giant Magnus field in the early 1980s. It took an overcautious view of the forecast production plan and built too small a platform, constraining production and obliging the company to pump for an expensive extended period rather than following the optimal path of build up, brief peak, and long decline. Had proactive flexibility been considered, higher production might have been achieved.

Where the company has taken proactive flexibility into account, the results have been remarkable.[1] BP's handling of the Andrew field is an example. The field was discovered in the mid-1970s but not developed at the time because it was small and, given the drilling technology of those days, required a huge investment. The oil price collapse required to develop an oil-block license often stays flat even if the price of oil soars, empowering managers to defer the proprietary investment opportunity without increasing the exercise price.

Minimizing obligations. Financial options impose no obligation to invest; therefore, investors are protected if the stock price falls below the exercise price. Real-options strategies strive to incorporate this feature into real-market investments, minimizing managers' obligations in situations characterized by uncertainty and irreversibility.

The application of real options steers management toward maximizing opportunity while minimizing obligation, encouraging companies to think of every situation as an initial investment against future possibility. As a

of the mid-1980s and subsequent market volatility made the prospect of development even dimmer. Yet by the mid-1990s, through the application of "breakthrough thinking," experimentation, the creation of learning networks, and benchmarking, BP had developed radical approaches to drilling, field development, project management, and the sharing of benefits with the contracting industry. In effect, BP bought an out-of-the-money option to develop the Andrew field, deferred exercising the option until the company had proactively driven down the exercise price, and then exercised an option that it had turned into an in-the-money one.

It should now be clear that the lessons of real-options thinking apply as much to existing assets as to new areas of exploration and development, where they are much more often applied. Declining or exhausted oil fields are a case in point. Net-present-value (NPV) analysis would probably suggest that they be closed down. But keeping them running not only defers new investment and saves the cost of removing redundant facilities (which is sometimes much higher than expected, as the enormously expensive Brent Spar incident two years ago showed)[2] but also retains the option of benefiting from the development of new technologies.

In these circumstances, the importance of options thinking lies less in the way the present values of cash inflows and outflows are managed and more in the recognition of the value of the option's duration. By exercising options to extend the life of its existing infrastructure (thus driving down development costs) and by managing competitors' and its own incremental investments—variables that NPV ignores or oversimplifies—BP has managed to commercialize many small oil fields as its original giant fields have declined.

[1] See "Unleashing the power of learning: An interview with British Petroleum's John Browne," *Harvard Business Review*, September–October 1997, for BP's own account of its value-creating strategy since 1992.

[2] Shell sought to sink the redundant storage platform Brent Spar in the mid-Atlantic, arousing a storm of protest.

result, management's field of vision is extended beyond long-term plans too rarely reexamined in order to encompass the full range of changing opportunities. Real-options thinking achieves this through its most basic contribution and most striking departure from the dictum of net present value: the attitude it fosters to uncertainty.

In an increasingly uncertain world, real options have broad application as a management tool. They will change the way you value opportunities. They will change the way you create value—both reactively and proactively. And they will change the way you think.