The real power of real options

The case for applying options thinking to any strategic situation

Adapting Black–Scholes to identify the right issues and the right actions

You may want to increase *uncertainty*

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OVER 30 YEARS OF OPERATION, one North Sea oil company accumulated a portfolio of licence blocks – five-year rights to explore and produce oil and gas. Where net present value (NPV) suggested 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 appeal as investment opportunities, the company decided to sell them to other companies that would buy them, cheaply, for reasons of geography or strategic fit.

Part way through the divestment program, it was suggested to the company's managers that, instead of calculating what the blocks would be worth if they started developing them today, they should value the opportunity as an *option* to develop if, at some point in the future, recoverable reserves could be increased through the use of new drilling and production technologies. In other words, they should apply the notion of options as conceived in financial markets to their actual business situation.

A simple financial model showed the managers how to price blocks at their *option value* over five years, incorporating uncertainty over the reserve size and oil prices, and leaving room for flexible response to the outcome. The managers reevaluated

Editor's note: As this issue went to press, Myron Scholes and Robert Merton were awarded the 1997 Nobel Prize for economics for their financial options valuation model. Fischer Black, who died in 1995, was mentioned in the award.

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their portfolio, and instead of letting the blocks go for a notional amount, decided to hold on to those with high option value and sell or trade the rest at their revised worth.

The above case is a simple application of real options to a business situation. It builds on the model developed for financial options by Fischer Black and Myron Scholes[1] as modified by Robert Merton, and specifically on the observation by Stewart Myers of MIT that Black–Scholes could be used to value investment opportunities in real markets – the markets for products and services. Over the past decade, the theory has been the subject of a growing body of literature and has gathered support across the business world in academia, consulting, and the corporation. Professors Avinash Dixit and Robert Pindyck insist that “the net present value rule is not sufficient. To make intelligent investment choices, managers need to consider the value of keeping their options open.”[2] Tom Copeland and Jon Weiner of McKinsey observe that the “use of options methodology gives managers a better handle on uncertainty.”[3] Judy Lewent, chief financial officer of Merck, suggests that all business decisions are real options, in that they confer the *right* but not the *obligation* to take some initiative in the future.[4]

As the North Sea example indicates, the value of keeping one’s options open is clearest in investment-intensive industries such as oil extraction. The licensing, exploration, appraisal, and development process also falls naturally into stages, each of which is pursued or abandoned according to the results of the previous stage. It follows therefore that the first stage, licensing and oil block, represents the purchase of an option on subsequent stages.

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 cashflows without fully committing to investments until the potential is confirmed. So why is it that others have not recognized or applied the power of real options in managing their businesses – despite the growing support the theory is attracting in academia and its apparent relevance in business decisions? At a minimum, one would expect real options to be broadly applied in industries characterized by high levels of R&D, manufacturing, and marketing investment.

The reason for this apparent neglect may be that options theory is notoriously arcane. To be sure, many discussions in the literature get bogged down in the

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1 “The pricing of options and corporate liabilities,” *Journal of Political Economy,* Vol. 81, No. 3, 1973, pp. 637–54.

2 “The options approach to capital investment,” *Harvard Business Review,* May–June 1995.

3 “Proactive management of uncertainty,” *The McKinsey Quarterly,* 1990 Number 4, pp. 133–52.

4 “Scientific management at Merck: An interview with CFO Judy Lewent,” *Harvard Business Review,* January–February 1994.

mathematics of Black–Scholes valuation when they go beyond the conceptual level. We believe, however, that managers don't need to be deeply conversant with the calculation techniques of real-option valuation. Just as many investments are made by managers who have only a passing acquaintance with the capital asset pricing model (CAPM) and the subtleties of estimating the cost of capital and terminal values for NPV calculations, so the fundamental insights of real-option theory can be used by managers who have no more than a basic understanding of option-pricing models.

There is another compelling reason why managers should grasp the insights behind real options. While option-pricing models are indeed a superior *valuation* tool – the purpose to which the theory is generally put – we believe real options can provide a systematic framework that will also serve as a *strategic* tool, and that it is in this strategic application that the real power of real options lies.

It is just such a framework that this article seeks to provide. We begin by developing the parallels between financial options and real options. We go on to demonstrate the power of real-option valuation as compared with traditional NPV analysis. A real option confers certain *reactive flexibilities* on its holder – essentially, the option to invest, wait, or divest in response to new information. Its sensitivity to the value of these possibilities is what makes a real option a better valuation tool than NPV.

However, we believe insufficient attention has been paid to the way in which the determinants of option value identify *proactive flexibilities* – the flexibility to take action in ways that will enhance the value of an option once acquired. Accordingly, we show how the real-options framework helps you identify and prioritize the key levers you can pull to increase the option payoff. In order to illustrate its validity in the real world, we then relate this framework to the way in which two successful companies operating in highly uncertain markets, British Petroleum and PowerGen, have intuitively exploited real options to create shareholder value.

The formal analysis of real options as a strategic rather than simply a valuation tool – as offering, that is, proactive rather than just reactive flexibility – represents, in our view, an advance on current thinking in this area.

What are real options?

In financial markets, purchasing an option bestows the right (but not the obligation) to buy or sell a stock at a fixed price within a fixed period. On January 14, 1997, when Merck was trading at $83, for example, a buyer could have paid $17 for a one-year option to buy Merck stock at an exercise price of $70. If the buyer had exercised the option on that same day, the payoff would have been $13 (the net present value); however, having spent $17 on the option, the buyer would be $4 out of pocket, this sum representing the premium he or she paid for the flexibility to wait and exercise the option if and when the stock price increased later in the year.

Generally, if stock exceeds the option exercise price, an investor's net payoff is the amount by which the stock price at the moment of exercise exceeds the exercise price, less the price paid for the option. If the stock falls below the exercise price, the investor is not obliged to exercise the option, and hence loses only the price paid for it (unlike a stockholder, who bears the entire downside).

Advocates of real options suggest that the thinking behind financial options may be extended to opportunities in real markets that offer, for a fixed cost, the right to realize future payoffs in return for further fixed (that is, independent of the asset value) investments, but without imposing any obligation to invest. Seen in these terms, the parallel between owning a North Sea oil licence and owning an option on Merck stock becomes clear. By paying a fixed licence fee to the government, the oil company buys a real option: the right to realize payoffs at any time over the next five years by making further fixed investments (independent of the future value of the oil block), but with no obligation to develop the block.

Companies in every type of industry have to allocate resources to competing opportunities. 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. It is because each of these choices creates a set of payoffs linked to further choices down the line that all management decisions can be thought of in terms of options.

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:[5]

$$Se^{-\delta t} * \{N(d_1)\} - Xe^{-rt} * \{N(d_2)\},$$

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

$d_2 = d_1 - \sigma * \sqrt{t}$,

and where S = stock price, X = exercise price, δ = dividends, r = risk-free rate, σ = uncertainty, t = time to expiry, and $N(d)$ = cumulative normal distribution function.[6]

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5 The original Black–Scholes 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. The above formula, as modified by Robert Merton, 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.

6 $N(d_1)$ = 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.

The **stock price** (S) is the value of the underlying stock on which an option is purchased. As such, it is simply the market's estimate of the present value of all future cashflows – dividends, capital gains, and so on – associated with that stock. Its equivalent in a real option is, therefore, the present value of cashflows expected from the investment opportunity on which the option is purchased.

The **exercise price** (X) is the predetermined price at which the option can be exercised. Its real-market equivalent is the present value of all the fixed costs expected over the lifetime of the investment opportunity.

Uncertainty (σ) is a measure of the unpredictability of future stock price movements: more precisely, the standard deviation of the growth rate of the value of future cash inflows associated with the stock. The real-market equivalent is the same, but in relation to the cashflows associated with the asset.

Time to expiry (t) is the period during which the option can be exercised. Its real-market equivalent is 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, licences).

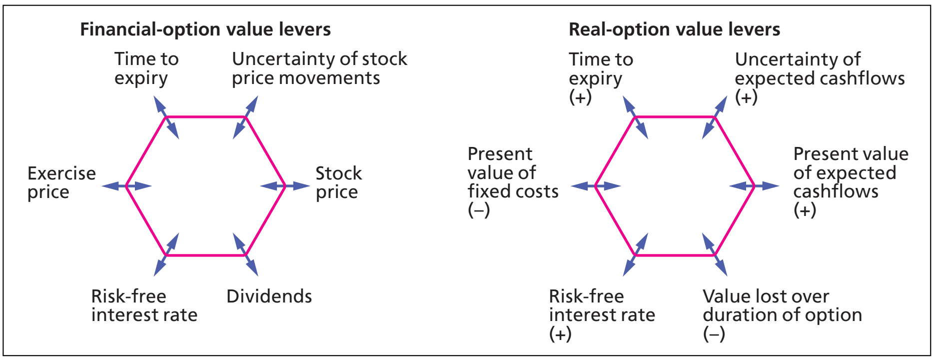
Dividends (δ) are sums paid regularly to stockholders. In real-market terms, dividend expense is represented by the value that drains away over the duration of the option. This could be the costs incurred to preserve the option (by staving off competition or keeping the opportunity alive), or the cashflows lost to competitors that go ahead and invest in an opportunity, depriving later entrants of cashflows.

The **risk-free interest rate** (r) is the yield of a riskless security with the same maturity as the duration of the option, whether with regard to financial options or real options.

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).

Exhibit 1

The six levers of financial and real options



Why real options are important

Real options are important in strategic and financial analysis because traditional valuation tools such as NPV ignore the value of flexibility. To view a corporation as a set of businesses, each with an NPV, creates a static picture of existing investments and opportunities. In many cases, it provides a basic mechanism for keeping score; in many other cases, however, it does not.

Consider again the oil company valuing its licence blocks. This is a classic example of a real option, in which paying the licence fee (acquiring the option) gives the owner the right to invest (at the exercise price) after uncertainty over the value of the developed reserves (stock price) is resolved.

In a similar case, another oil company has the opportunity to acquire a five-year licence 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:

$$\$500 \text{ million} - \$600 \text{ million} = -\$100 \text{ million.}$$

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

But what would option valuation make of the same case? To begin with, such a valuation would recognize the importance of uncertainty, which the NPV analysis effectively assumes away. There are two major sources of uncertainty affecting the value of the block: the quantity and the price of the oil. One 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 is 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 one 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 (ie, 15/500) of the value of the asset. We already know that the duration of the option, *t,* is five years and the risk-free rate, *r,* is 5 percent, leading us to estimate option value at

$$\text{ROV} = (500e^{-0.03*5})*\{(0.58)\}-(600e^{-0.05*5})*\{(0.32)\}$$
$$= \$251 \text{ million} - \$151 \text{ million} = +\$100 \text{ million.}$$ [7]

Where does this $200 million difference come from? Recall the Merck option, available at $17 for an exercise price of $70 when the stock traded at $83.

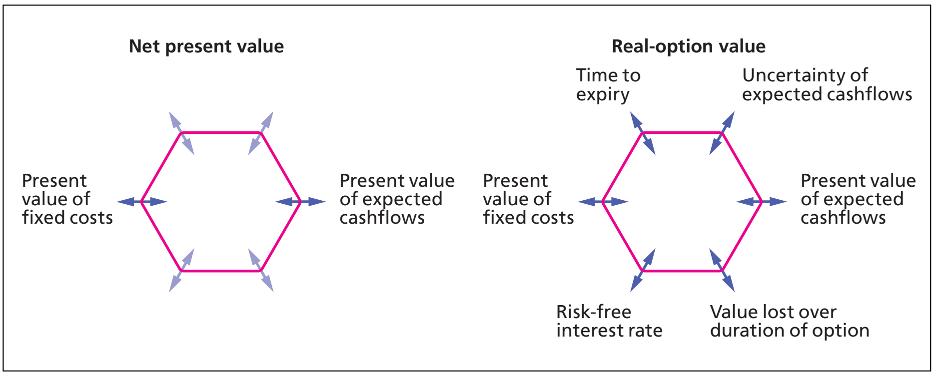
[7] This valuation is simplistic in that it makes a restrictive set of assumptions (such as log-normal distribution of asset value and constancy of dividend, uncertainty, and interest rates) that are imposed by the analytical approach. McKinsey's Strategy Metrics Initiative is addressing some of these real-world complications through numerical approaches such as lattice valuation methodology and Monte Carlo simulation.

There, a $4 premium was charged, the value of which an NPV analysis would recognize as zero. This $4 represented the value of the flexibility inherent in not having to decide on full investment today, but instead being able to wait and invest when uncertainty is resolved. So too in this case: the $200 million is the equivalent of the $4.[8]

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 does not properly recognize the value of learning more before a full commitment is made, is for that reason often inadequate. In fact, its 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 cashflows and the present value of fixed costs (Exhibit 2). The greater comprehensiveness of option valuation can therefore be summed up in this way: it captures NPV plus flexibility value – effectively, the expected value of the change in NPV over the option's life.

Exhibit 2

Comparison of valuation methodologies



Essentially, NPV can mislead whenever there is flexibility, especially flexibility to respond to uncertainty over the rate of cashflow growth, because it incorporates only two key levers of value creation. It assumes, that is, that the present values of both cash inflows and cash outflows are static. Practitioners who are aware of NPV's shortcomings tend to rely on techniques such as scenario analysis to capture the fact that these values must necessarily be *ranges* and not single numbers. Using high, low, or medium scenarios helps to bound the uncertainty, but it does not help to incorporate into the valuation the variance across the different scenarios. Scenario thinking recognizes that uncertainty exists, but does not capture the

8 The Merck option is an in-the-money (positive NPV) financial option, since the stock price of $83 is greater than the exercise price of $70, whereas the oil lease is an out-of-the-money (negative NPV) real option, since the value of the inflows, $500 million, is less than the value of the outflows, $600 million. However, in both cases, an explicit consideration of flexibility value improves the economic analysis and decision making.

flexibility value inherent in a situation, and hence offers little managerial guidance. In contrast, real options provide a comprehensive valuation model for any strategic situation, however uncertain.

Leveraging flexibility: The strategic *value of real options*

Some flexibilities 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* flexibilities: flexibilities an option holder exploits to respond to environmental conditions and maximize his or her payoff.

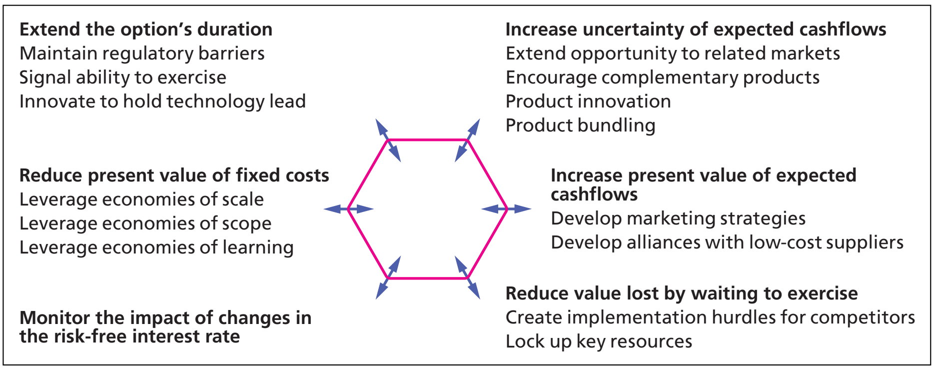
When we talk about the reactive flexibilities of a real option, however, we are ultimately talking only about its advantages as a valuation tool. The further, typically larger, payoff comes from the **proactive flexibility to increase the value of an option, once acquired.** This opportunity arises from the fact that, whereas a financial option is acquired and exercised in a deep and transparent market, real business situations usually feature a limited number of players interacting with one another, each of which can influence the real-option levers and hence the option value.

A manager in a pharmaceutical company, for example, has the flexibility to influence a real-option lever such as the present value of a project's cash inflows (stock price) by increasing the resources put into marketing. He or she might be able to increase the option's duration (time to expiry) by securing a product patent or renegotiating a licensing agreement. These actions would, of course, also affect the value of the options held by other players.

The advantage of proactive flexibility is that management can use their skills to improve an option's value before they exercise it, effectively making it worth more than the price paid to acquire or create it. They do this by pulling the levers that control its value.

Exhibit 3

Managing real options proactively



Managing proactive flexibility

One of the advantages of using the modified Black–Scholes equation for real options is that it identifies, by definition, the issues crucial to maximizing an option's value. Because the value of a real option is determined by the six levers illustrated in Exhibit 3, exploiting proactive flexibility becomes simply a question of pulling one or more levers.

Lever 1: Increase the present value of expected operating cash inflows. This is achieved by increasing revenues, either 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.")[9]

Lever 2: Reduce the present value of expected operating cash outflows. There are two basic ways to cut costs: by leveraging economies of scale (the cost per unit of falls as the number of units rises), or by 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 cashflows. Greater uncertainty raises option value, because it increases the value of flexibility. This is perhaps the crucial difference from 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. When a company has only bought an option, however, it has not bet the entire value of the 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 with 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 licence blocks. A few, however, have pursued an option-based strategy. They actively encourage competitive entry into a geological area, and defer their investments until competitive activity has picked up. This strategy increases the uncertainty over the potential revenues in the shallow gas markets, but provides two benefits. First, these companies leverage their reactive flexibility to make more informed investment decisions based on new information from competitive activity at the optimal moment. Second, they leverage their

[9] Compound options are options that offer the additional flexibility to make subsequent investments or divestments. For instance, an oil company investing in a new oilfield has the flexibility to scale up after uncertainties are resolved, which in turn may lead to further flexibilities to scope up its operations.

proactive flexibility to secure better prices from customers nervous about the uncertainty over the supply of gas.[10]

Lever 4: Extend the opportunity's duration. This raises an option's value because it increases total uncertainty. In the licence block example, the company might be able to prolong its option by, for instance, extending the licence with the awarding government, extending exclusive raw material supply contracts, locking up distribution channels for a product, or capturing "bottleneck" assets.

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 could be high if an early entrant were to seize the initiative.[11] 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: by locking up key customers or lobbying for regulatory constraints, for example.

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

Choose your levers

Which levers should a company pull? Which levers *can* it pull? The first question is one of economic priority, and can be determined by a straightforward sensitivity analysis.

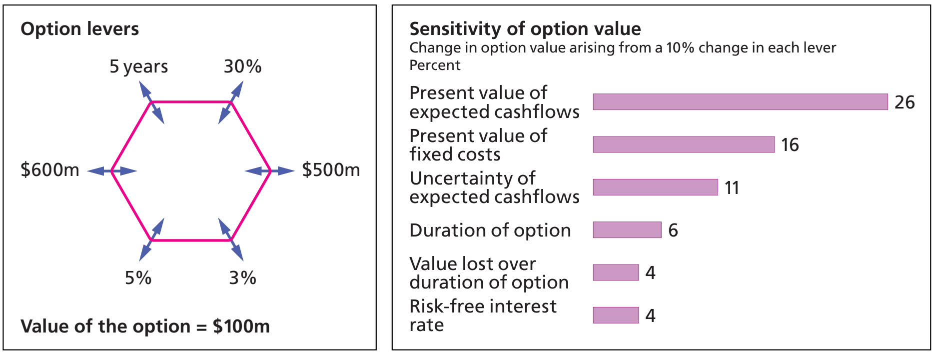
Take, once again, the example of the licence blocks, which real-option valuation judged to be worth $100 million, and NPV analysis *minus* $100 million. As Exhibit 4 shows, sensitivity analysis of the six levers quickly identifies potential economic priorities. The exhibit shows the effect on option value of a 10 percent increase in each lever. We see immediately that, as with

10 The price of *oil* cannot be influenced by any company because of the ease of transporting oil to a global, deep, transparent market. However, *natural gas* markets are typically local and opaque because of the difficulty of storing and transporting gas. The greater the uncertainty over future investment (and therefore production) plans, the greater the price volatility; and the greater the incentive for gas buyers to commit to high-priced supply, the greater the option value of a licence block. Companies must weigh the value created by waiting against the value lost through delay in developing the licence blocks and subsequent delays in the supply of gas.

11 We use an already committed player to make the parallel with financial options perfect, because the dividend is paid to a current (rather than a potential) shareholder. In real options, one could extend this logic to include potential entrants without doing serious damage to the analogy.

Exhibit 4

Pulling the real option levers



the valuation of any option, 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 and 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.

So it appears to be better 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" (ie, annual costs) by 10 percent can together yield a significant return.

The question of which levers can be pulled is simply one of the internal and external constraints on the operations of the company. These might be technical, or have to do with marketing, negotiating, or contractor management issues. They would also concern investment-specific factors such as the delay between investment and payoff and the indivisibility of investments (that is, constraints on incremental investment). When all these factors are taken into account, an option can generally be classified under one of three categories:

High-priority options, where option value is highly sensitive to levers that management can readily pull: for instance, the application of horizontal drilling techniques to maximize recoverable reserves of oil.

Medium-priority options, where option value is sensitive to levers that at least one other competitor, but not the current owner, could pull right away. In these cases, management can simply sell the option to its natural owner (unless it has reason to build or buy the relevant capability itself). The option to extend the duration of a North Sea licence block is likely to be of greater value to an established operator with existing infrastructure than to an operator making a one-off investment.

Low-priority options, where option value is not at all sensitive to the levers that any player could pull. Sometimes high option value can be calculated in theory, but is not likely to be realized because the levers are beyond any one company's reach. Many options fall into this category, including options to expand capacity in petrochemicals or petroleum refining in Europe.

A way of thinking

The final, and perhaps greatest, benefit of real-option 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. NPV analyses typically assume a fixed, multi-year investment model against a fixed expectation of annual return. Multi-year investments are of course reanalyzed at least annually. Nevertheless, the mindset of taking one-time decisions on the basis of static investment plans tends to narrow the vision. It is often possible dynamically to change course or even abandon a multi-year investment project once it has been undertaken, but managers who are used to a static mindset – and who may have submitted project forecasts for many years ahead – find it much harder to change course.

Above all, real-option strategies are distinguished from traditional strategies by their response to uncertainty. The shift in outlook from "fear of uncertainty/minimize investment" to "seek gains from uncertainty/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. With hindsight, the resulting actions frequently seem obvious – but that is merely the mark of an effective model.

There are four ways in which the discipline of applying real-option analysis to every investment possibility will improve a company's strategies:

By emphasizing opportunities. A real-option strategy emphasizes the logic of strategic opportunism. It forces managers to compare every incremental opportunity arising from existing investments with the full range of opportunities open to them. A manager considering investing $10 million in an existing oilfield should compare the option value with that of investing in a satellite gas field, for example. Such an approach is especially important in mature industries, where managerial inertia often manifests itself as escalating commitment. It is not uncommon in the oil industry, for instance, for managers to respond to the uncertainty surrounding new projects by imposing a higher discount rate hurdle on them in NPV analysis. This subjective bias toward incremental investment in established projects and away from uncertainty is corrected by the objective bias *toward* uncertainty imposed by the discipline of options thinking.

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

By maximizing rights. Investors in financial options acquire a right to an opportunity: in the case of the Merck option, the exercise price of $70 remains fixed until the option expires even if the stock price rockets, preserving for the investor the exclusive right to all payoffs. Such investment and divestment opportunities exist in real markets too. The investment required to develop an oil-block licence, for example, often stays flat even if the oil price soars. This empowers managers to defer the proprietary investment opportunity without increasing the exercise price.

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

Best practice in managing real options

Two UK companies, BP and PowerGen, exemplify the benefits of real-options thinking. Between 1990 and 1996, BP increased its market value from $18 billion to $30 billion, representing a total return to shareholders of 167 percent. Over the same period, PowerGen raised its market value from $1.4 billion to $3.8 billion, a return of almost 300 percent.

In both cases, most assets and earnings were in mature industries. BP's exploitation of North Sea oil and gas field development options took place against a background of falling reservoir sizes and volatile oil and gas prices – quite unlike the boom days of the 1970s and early 1980s. PowerGen, for its part, has had to deal with barely rising demand, a saturated market, and increasing competition to build new capacity.

Both companies managed to earn extraordinary returns in unfavorable environments because they followed a strategy of making incremental investments to secure the upside while insuring against the downside. They also delayed committing to investment until they had confirmed that it would be worth while, usually by acting on the six levers of option value.

BP: Maximizing the value of new – and old – oilfields

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 licence 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.

While correct, this description captures no more than the value of the real option's reactive flexibility. Had BP acted on reactive flexibilities alone, it would probably not be earning superior returns in mature provinces like the North Sea, where profitable low-risk investment opportunities were exhausted long ago. By the same token, new opportunities such as those west of Shetland and in certain high-pressure/high-temperature areas of the UK continental shelf require heavy capital investment and carry geological and technical risks, so they usually appear uneconomic under NPV analysis. But because cumulative holding costs are so low, and the payoff can be huge if the geological, technical, and partnership uncertainties are resolved, almost *any* option value justifies holding on to such leases.

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 over-cautious view of the forecast production plan and built too small a platform. Had proactive flexibilities been considered, higher production might have been achieved. As it was, production was constrained, and Magnus was obliged to pump for an expensive extended period, rather than following the optimal path of build-up, brief peak, and long decline.

When the company has taken proactive flexibilities into account, however, the results have been remarkable.[12] Its 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 huge investment. The oil price collapse 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. What

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[12] *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.

the company did, in effect, was to buy an out-of-the-money option to develop the Andrew field, defer exercising the option until it had proactively driven down the exercise price (that is, the investment in development), and then exercise an option that it had turned into an in-the-money one.

Exploiting proactive flexibility in the case of oilfield development licences involves all the steps to reduce capital costs that BP took in the case of the Andrew field, along with measures to minimize the cost of the real option. The license bid and its holding cost are the option price – as critical a part of the management equation as the six levers of option value (the same is true in financial options). The holding cost can be reduced by renegotiating spending commitments such as a commitment to a government to drill exploration wells, or a commitment to a partner.

As always, it is worth comparing real-options thinking, reactive and proactive, with NPV along the six levers of the options model. The most sensitive levers are increasing the present value of expected cash inflows and reducing the present value of expected fixed costs. The means to pull both these levers is the application of new technology to obtain more reliable profiles of an oilfield's value, better total oil recovery, and more efficient production facilities (fewer wells, lighter platforms). The next most sensitive lever, increased uncertainty and hence price volatility, makes an option more attractive, but management cannot influence oil prices. At the less sensitive end of the spectrum, the option's duration should be managed to trade off potential improvements in cash inflow and outflow against the cost of holding the option and the risk of losing "dividends."

The lessons of real-options thinking apply as much to existing assets as to new areas of exploration and development

NPV analysis could allow for some of this potential through different scenarios. The danger, however, is that a classic NPV "go/no go" all-or-nothing decision would underestimate the value of expected cash inflows, which could result in a production facility incapable of handling higher than expected volume, as in the case of the Magnus field. NPV analysis would seriously undervalue volatility, accentuating the risk-averse behavior already skewing forecasts and budgeting. "Go/no go" thinking also implicitly assumes (usually incorrectly) that the investment opportunity will be unaffected by competitor behavior.

It should be clear by now that the lessons of real-options thinking apply as much to existing assets as they do to new areas of exploration and development, where they are much more often applied. Declining or exhausted oilfields are a case in point. NPV analysis would probably suggest they be closed down. But keeping them running not only effectively defers new investment and saves the cost of removing redundant facilities (sometimes much higher than anticipated, as the enormously expensive Brent Spar incident two years ago showed),[13] it also keeps open the option of benefiting from the development of new technologies. For instance, satellite unmanned gas platforms in the southern North Sea, extended-reach drilling (enabling wells to be bored into a reservoir tens of kilometres from a platform originally installed to service a nearby reservoir), and sub-sea templates that pump oil back to far-off platforms all make it possible to use processing capacity that would otherwise have become surplus as soon as the original reservoirs were exhausted. Such developments have greatly increased the option value of fields originally exploited with no thought of such possibilities.

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 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 oilfields as its original giant fields have declined.

PowerGen: Flexible operating strategies of the power station

In 1990, the British government privatized the electricity generating industry. At a stroke, the stable market enjoyed by a state-owned monopoly was replaced by an unpredictable environment of fluctuating prices. A pool (or spot market) was established into which generators had to sell their electricity, and which priced electricity by the half-hour on the basis of bids from power stations. The new market is characterized by hour-to-hour and seasonal volatility – a nightmare for generators in a highly capital-intensive industry.

At the time, most generating stations were coal-fired "baseload" stations designed to generate more or less continuously. The variable nature of electricity demand and the availability of environmentally and economically attractive supplies of natural gas fueled the "dash for gas": the development of combined-cycle gas turbine (CCGT) stations that could be switched on or off according to requirements, reaching full capacity without technical problems in 15 minutes. Most coal stations – PowerGen's among them – were forced out of baseload into periodic production, to which they were unsuited. Many were forced to close.

NPV analysis of the dilemma faced by coal-fired stations would have suggested driving down costs (an insufficient measure given the superior economics of CCGT) or hedging electricity output (which would have protected against the downside risk of losing market share, but only at the

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

price of eliminating the upside potential), or closing the plant to avoid investing against an uncertain cash inflow. Real-options thinking, however, enabled PowerGen to exploit three variables ignored in NPV thinking – uncertainty, duration, and dividend – to create a profitable business.

Price volatility meant that for short periods, coal stations could earn large margins and would thus be worth life-extending investment, provided that PowerGen's operating staff rapidly developed the technological and operational flexibility to acquire two key capabilities (Exhibit 5):

- The ability to switch coal plant on and off frequently. New operating skills such as managing the chemical balance in the boilers, in combination with limited investment such as the use of hardened chrome headers to prevent boilers cracking as tubes heat and cool, now enable some PowerGen stations to start up more than 200 times a year. Typical US coal-fired stations start up just eight to ten times a year.

- The ability to bid economically for marginal business by converting fixed costs into variable costs through the aggressive use of contractors.

Exhibit 5

Real-option valuation and strategy versus the NPV approach

Example	**Net present value**	**Real-option valuation** (reactive flexibility)	**Real-option strategy** (reactive *and* proactive flexibility)
BP: Maximizing the value of Andrew field	Sell/surrender licence blocks immediately	Still sell/surrender because oil price volatility does not increase value sufficiently	Increase present value of future cash inflows by maximizing recoverable reserves; reduce drilling and platform costs
PowerGen: Flexible operation of the power station	Shut coal-fired power stations immediately	Still shut most coal-fired power stations because they are unsuited to on/off operation	Reduce exercise price by introducing flexible start/stop operation and transforming fixed costs into variable costs

Rather like BP, PowerGen raised its aspirations by benchmarking, by stretching its management to surpass world best practice, and by freeing business units and teams to find the best route forward. PowerGen ultimately enjoyed a double benefit, in fact, because unpredictable shutdowns of nuclear plants, combined with volatilities in supply and demand, have caused periodic shifts to coal production and an increase in prices.

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The application of real options steers management toward maximizing opportunity while minimizing obligation, encouraging it to think of every situation as an initial investment against future possibility. As a result, management's field of vision is extended beyond long-term plans too rarely properly reexamined, to encompass the full range of opportunities available to it at any moment. Real-options thinking achieves this through its most basic contribution and its most striking departure from the dicta of net present value: the attitude it fosters to uncertainty.

For BP, the economics of a prospective oil or gas field are highly uncertain in terms of margins (oil prices fluctuate, operating costs are unpredictable) and volume (recoverable reserves are difficult to estimate at the start of the licensing, exploration, appraisal, and development process). The company has responded by embracing uncertainty. It has increased its exposure to volatile undeveloped prospects by accumulating licences that exploit the flexibility to respond to new technology and operating practices in order to make currently uneconomic prospects profitable. It is a strategy that has transformed BP's view of the North Sea's potential.

For PowerGen, the electricity pool is uncertain in terms of price and volume. The company's strategy evolved from "secure baseload with minimal uncertainty" to "explore opportunistic operating strategies." The outcome was a shift from an NPV approach that would have maximized the baseload volume of a few plants and closed all the others, to a policy of increasing operational flexibilities to respond to the market – and capturing marginal volumes at high prices.

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.

of interest...

PROACTIVE MANAGEMENT OF UNCERTAINTY

"A fascinating aspect of flexibility options is that in certain cases it is possible to estimate their value precisely. Often, the extra value added by flexibility is completely missing from such traditional valuation methodologies as net present value (NPV) techniques. In fact, one contributing factor to underinvestment in the United States may be the slavish dedication of its MBA-trained managers to NPV. Have you ever sat at a meeting and listened to a careful NPV analysis, known in your gut that the recommendation had to be wrong, but could not put your finger on the reason? The missing ingredient may be the value of flexibility."

Tom Copeland and Jon Weiner, *The McKinsey Quarterly,* 1990 Number 4