Using scenario thinking to make real options relevant to managers: a case illustration

Roger W. Mills

Professor of Finance and Accounting and Executive Director, Henley Centre for Value Improvement (HCVI), Henley Management College, Henley, United Kingdom

Bill Weinstein

Professor of International Business, Director HCVI, Henley Management College, Henley, United Kingdom

Dr Giampiero Favato

Director HCVI, Henley Management College, Henley, United Kingdom

This paper argues the advantages of Real Options thinking and by means of examples, exhibits the types of decision-making calculations that are distinctive to Real Options. However, in the process of clarifying the application of Real Options analysis to real decision making, a strong dependency upon scenario thinking is established. The value to decision makers of Real Options depends crucially on the substance and use of the scenarios on which it rests. The distinctive contribution of this paper consists in substantiating this view.

By forging a critical link between Real Options analysis and scenario thinking, this paper illustrates how the beneficial application of Real Options to decision making brings it down from the esoteric heights of mathematics, converts it into a technique readily accessible to managers and qualifies it for inclusion in the curriculum of management education. Two cases drawn from personal experience are used to illustrate the approach recommended by the authors.

Introduction: the strategic intent of this paper

The history of the sciences is marked by several successes in converting highly complex and esoteric calculative processes into ones that are accessible to and usable by 'lay' people who are not at the cutting edge of the subject. Famously, there was the myth that Einstein's Theory of Relativity could be understood by only a handful of geniuses. Years later the theory became a standard part of the curriculum of postgraduate physics students, then undergraduates and ultimately, advanced school children. There are today many areas of finance and accounting that remain the preserve of the financial specialist: it is undeniable that in the present state of the art, the Real Options approach to decision making remains unknown territory to the vast majority of managers.

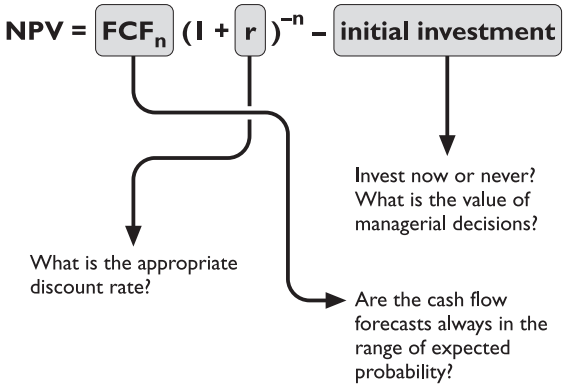
What is this approach? The term 'Real Options' (as distinct from financial options) was coined by Stewart Myers (1977) and referred to the application of option pricing theory, as conventionally applied to shares, to the valuation of investments in non-financial or 'real' assets where much of the value is attributable to flexibility and learning over time. This means that the opportunity inherent in a capital project can be viewed as implied contracts that allow management to choose only those actions that have positive cash flow effects. In keeping with the principles of financial options, a Real Option conveys the right to buy or sell, for which a price must typically be paid, rather than the necessity to buy or sell the underlying asset(s). Why 'Real' options? The underlying assets of the options in a capital investment decision are real assets like the development of a new plant rather than financial assets, like stocks and shares and, as a consequence, the options embedded in the investment decisions are referred to as 'Real Options' as opposed to financial options.

In the area of decision making, the scope for error is rife. It is an area for rational structuring, as has been attempted for many years, but few techniques have penetrated beyond the complexities captured by the decision theory staff or specialised consultants who advise line managers. It will be demonstrated that there is a high priority need to make more accessible and usable to managers an approach to Real Options which is crucial to the strategic direction and choice-making for their enterprises. At present, there is a dividing wall. To those engaged in developing Real Options thinking it is almost incomprehensible why it is not used for strategic decision-making in the real management world. To others, Real Options analysis is not a usable tool unless there is a superb interpreter or translator available – and proof over time of better results than those arising from alternatives.

This paper is therefore positioned to breach that wall. It stands or falls as an attempt to execute that translation process for decision makers without distorting or compromising its essential quality, which is often embedded in unfamiliar mathematical manoeuvres. This is a quest to achieve usability; and it is highly likely that in a few years time much of the complexity will be reduced to simple and familiar formulae that will be programmed into a computer for use by managers. Lack of success in this enterprise condemns managers to two outcomes. Either they will fail to understand and critically evaluate professional advice given to them by experts in Real Options (a risky dependency), or they will be deprived of a rational technique for anticipating the means of adding value or preventing its destruction.

The options approach to facilitate managerial decision making

Research undertaken in the last two decades has shown that managers in diverse fields tend to make the same kind of decision-making mistakes. Of these, the single most common decision trap is referred to as 'frame blindness', i.e. setting out to solve the wrong problem because a mental framework has been created for a decision that causes the best option to be overlooked (Russo



Where:

FCF (free cash flow) = Net Operating Profit After Tax (NOPAT) – net investment – change in working capital
r = discount rate
n = investment period (years)

Figure 1: New economic and financial theories are challenging Net Present Value

and Shoemaker, 1989). In fact, the word 'option' is extremely relevant because in recent years, practitioners and academics have argued that traditional discounted cash flow models do not capture the value of options embedded in many corporate decisions. These options need to be considered, because their value can be substantial.

Companies in every type of industry have to make investment decisions, to allocate resources to competing opportunities. They have to decide whether to invest now, to take preliminary actions to preserve the right to invest in the future, or to do nothing. For such purposes, they use investment appraisal techniques. The theoretical underpinnings for the use of investment appraisal techniques were drawn from the economic theory of the firm which contends that corporate investment decisions should be guided by the rule of net present value (NPV) maximisation. This gave rise to the widely accepted capital budgeting tool of discounted cash flow (DCF) analysis, which measures a project's desirability on the basis of its expected NPV. However, the DCF model has not been without criticism (Mills, 1995).

Two particular defects of DCF analysis are important. First, it tends to overlook the strategic reasons for an investment, such as investing in a not-so-profitable project in order to acquire future growth opportunities (Hayes and Garvin, 1992). For example, in conditions where technology is changing rapidly, investments may be made for competitive reasons alone and such investments may well fail the DCF test (Clemons and Webber, 1990; Kaplan, 1986; Naj, 1990; Polakoff, 1990).

The second important criticism of DCF analysis is that it fails to take account of the value of active management. Such management might decide to wait for major uncertainties, say, over future market conditions, to unfold in order to avoid losses, or to undertake specific R&D expenditure intended to lead to new patents. Such options and the calculation of their potential value would not be included in the usual NPV reckoning. Active management aims to produce valuable information, thereby reducing uncertainty over the

future. Furthermore, subsequent to making an investment, management can revise operating plans that underlay an original cash flow forecast, like altering input and output mixes or shutting down plant temporarily in order to maximise operating cash flows. Quite simply, active management can affect a project's value, but it is not accounted for in conventional DCF analysis.

Researchers have examined the shortcomings of the conventional DCF and have shown that not only is it incomplete, but it may lead to costly errors (Dixit and Pindyck, 1995). These errors arise from two sources. First, investments guided by the positive NPV criteria may be made too hastily. This is a problem, because most capital investments are irreversible and thus justifiable only if the expected profit margin is sufficiently large. Second, conversely, worthwhile investments, based on the same criteria, may be rejected inadvertently. As a consequence, any theory of investment needs to address the question: how should a corporate manager facing uncertainty over future market conditions decide whether to invest in a new project?

Management has to decide when to invest, how operating plans should be modified during the life of the project, and whether to abandon a project in midstream. By guiding a project/investment from beginning to end, management may be able to squeeze its cash flow distribution towards a higher rate of return. This has led to the development of the idea that because management control can impact upon a project's payoff in terms of potential profits and losses, control opportunities can be seen as being analogous to 'call' and 'put' options and may be analysed using options pricing theory.

This theory has its origins in the valuation of stocks and shares, where a stock option is an explicit contract conferring certain rights upon the holder, who exercises the option only when it is profitable to do so. In fact, an option is a contract that creates an opportunity, but not an obligation, to buy (a 'call' option) or sell (a 'put' option) at an agreed price at a future date. As previously indicated, the options approach can be and has been extended in principle to capital projects, so that the opportunity inherent in a capital project can be viewed as Real Options, like implied contracts that allow management to choose only those actions that have positive cash flow effects.

Indeed, during the 1990s, finance researchers generated a plethora of Real Options models and statistical applets, with much of this work advancing the use of technical tools (differential equations, dynamic programming and Monte Carlo simulations) for pricing Real Options. The results of such work have not always placed the Real Options approach in the best light. For example, in a paper recently published, Alan Borison (2005) showed how five different Real Option valuation methodologies would approach the same problem (a case related to the purchase and development of an oil field) giving very different option values ranging from $19 million to $300 million.

At face value and from a managerial perspective, such a result appears damning to the Real Options approach, although Copeland and Antikarov (2005) subsequently demonstrated that by using a mutually consistent set of assumptions among the five different methods used by Borison, the range of values compressed considerably, from $279 million to about $12 million, an average difference of approximately 5%. Furthermore, using the same inputs as Copeland, the authors (Favato, Mills and Weinstein, 2005) took this

Assumptions:	
Underlying asset value	$225 mill
Exercise price	$175 mill
Volatility	25%
Time to expiration	2 years
Risk-free rate	3%
Dividends payout	0%

Pricing model	Option value	
Discrete-time model:	$ 66.100 m	(Copeland)
Continuous models:		
Black-Scholes method	$ 66.799 m	
Lattices:		
European Binomial	$ 67.2096 m	(10,000 steps)
European Trinomial	$ 67.2093 m	(10,000 steps)
Montecarlo Simulations:		
Monte Carlo	$ 67.4448 m	(10,000 simulations)
Quasi Monte Carlo	$ 67.1097 m	(10,000 simulations)
European Finite Difference	$ 67.1003 m	

Figure 2: Convergence of Real Option values using different pricing models under a consistent set of assumptions.

hypothesis further, demonstrating the substantial equivalence of results between a number of the most widely adopted stochastic models and the much more intuitive binomial method (see Figure 2). The charge that Real Options creates widely different results is therefore substantially challenged.

Like NPV analysis, the Real Options approach involves projecting future cash flows and choosing an appropriate discount or probability rate. However, unlike NPV analysis, the Real Options perspective assumes managers can influence the outcome by interventionist actions that add value over time (Anderson, 2000). For example, the purchase of a computer software company entitles the owner to the company's free cash flow, but the assets acquired in place are not the only opportunity purchased. Along with the assets there may also be the chance to acquire less tangible benefits, for example, to learn about other software companies that might be for sale.

The company may also include highly skilled individuals who could be used to produce extra at little cost, but with high value. Because such followon investment opportunities are relatively intangible and speculative, their expected cash flows are rarely examined directly. Nevertheless, these opportunities may have important value. This perception places Real Options on the interface between strategy and finance, albeit initially without quantification. In the cases that follow reference will be made to one primary approach, known as the Black-Scholes algorithm, where the following five factors are used to determine the project's option value:

1. Exercise price.
2. Stock price.
3. Time to expiration.
4. Project volatility.
5. Risk-free rate.

A specific illustration of the options approach using this approach has been provided by Sender (1994), executive director of financial evaluation and analysis at Merck. The company wanted to enter a new line of business that required the acquisition of a number of appropriate technologies from a small company. Under the terms of the proposed agreement, Merck would pay $2 million over a period of three years. In addition, Merck would pay royalties to the company should the product ever come to the market. Merck had the

option to terminate the agreement at any time if dissatisfied with the progress of the research. To use the approach it was necessary to provide inputs for the five factors which were:

1. **Exercise price:** this represented the cost of a capital investment to be made approximately two years hence.
2. **Stock price:** this represented the value of the underlying asset or the present value of the cash flows from the project (excluding the capital investment to be made and the present value of the up-front fees and development costs over the next two years).
3. **Time to expiration:** this ranged from two, three and four years, with the option being exercisable in two years at the earliest. The option was structured to expire in four years because Merck thought that competing products, making market entry unfeasible, would exist by then.
4. **Project volatility:** this was represented by a sample of the annual standard deviation of returns for typical biotechnology stocks obtained from an investment bank.
5. **Risk-free rate:** a US Treasury rate of 4.5% was used over the two to four year period referred to in the time to expiration of the model.

Despite the apparent relevance of Real Options to business decisions, it has had limited impact generally. For example, in a survey by the consulting company Bain (2000), 46 per cent of firms that experimented with Real Options analysis gave up. One problem frequently expressed is that options theory is regarded as being notoriously arcane and many discussions that go beyond the conceptual level get trapped in the mathematics. This may be a real problem, because in the authors' experience, many managers have only a passing acquaintance with the subtleties of the Net Present Value calculation and potentially stand little chance with more complex approaches like the Black-Scholes pricing model. This is unfortunate because Real Options are best understood as a way of thinking and need to be positioned correctly alongside an approach that creates coherent stories about possible future outcomes, which is the territory of scenario analysis.

Scenario planning and real options

In the 1970s, Scenario Planning gained prominence as a strategic management tool. It encourages managers to envision plausible future states of the world and consider how to take advantage of opportunities and avoid potential threats. Through Scenario Planning, the contingencies, uncertainties, trends and opportunities that are often unanticipated can be identified. While Scenario Planning is primarily a qualitative method of analysis used to identify risk, when combined with the Real Options approach it takes on a more quantitative identity, able to be used effectively in assessing value creation under conditions of uncertainty. Eventually, quantitative values have to be assigned to the probability and impact of each scenario on the critical factors determining investment outcomes.

A rigorous process of scenario analysis, based on hundreds of strategic workshops, has been expounded by Weinstein (1995). According to Wein-

stein, scenarios are not predictions or preferences but speculative descriptions of pathways in the future for a business unit or project. They operate with a minimum of two scenarios, often with four drawn from a two dimensional matrix, and can, of course, grow to a large number of alternatives. The point is that if scenarios are not plural, the sole so-called scenario is in effect a prediction, and the use of the typical scenario phrase 'what if . . . .?' becomes vacuous. A key reason for using scenarios is the fallibility of predictions. In advance of the developments which they depict, scenarios carry no guarantees of validity, but they widen the range of possible pathways and outcomes. Such widening increases the chances of capturing the salient future developments compared with single-line predictions.

Scenarios depict how the environment external to a business or unit may develop; but do not include what the business actions will be – the latter are supposed action and resource responses – *based on* the assessed impacts of scenarios but are not part of the scenarios themselves. Scenarios are one thing; action and resource responses to them are another. Thus, the 'active management' feature of Real Options is a response to a scenario and its outcomes. Although scenarios are evidence-based, they are projected into an uncertain future, and therefore subject to debate and credibility doubts. They are not definitive.

Often equally open to debate is the time scale of a scenario and whether comparison of scenarios should be on the same time scale, and whether the time scales of scenarios should be aligned with the time scale of a project, e.g. the development phase, or development plus a specified marketing goal, e.g. *x*% market share achieved. As scenarios can evolve in people's minds over time through searches for better or new evidence and new speculations, they are subject to revision as to their content and impact.

Many scenario users are familiar with the terms 'worst case', 'best case' and 'base case'. The implicit danger in using such labels is to draw conclusions before detailed impact analysis is undertaken, and to close mental doors as to the application of Real Options. Furthermore, as the 'base case' steers between best and worst, it seems more comforting and even more probable. The trap: building a value analysis of a project on a base case whose probability rating may be illusory. Experience of scenario work shows participants that it is not necessarily how radically different they are which can make them useful, but rather the difference that their respective *impacts* make upon the value of a business, including proposed changes such as R&D investment, merger and acquisition, territorial expansion, etc.

Of course the building of scenarios is crucial, and how one may group together or separate different developments in an external environment – e.g. market consolidation or fragmentation, product regulation and licensing, whether a competitor launches a successful new product or process, and much else – is a matter of personal and group judgments. Different combinations have to be tested for credibility and may be revised. This aggregation or disaggregation of scenario components defines the differences among scenarios and is a precondition of estimating their impacts.

In focusing on specific projects or strategic directions, the relevant scenarios need not be constructed as 'rich clusters' of many factors moving together in

the future, but rather be highly selective. That is, and as may be seen in the two cases which are examined in this paper, a single factor scenario may be extremely powerful in focusing on the 'killer' or 'make or break' factor for an investment. Single-factor scenarios may seem arbitrary but they could reflect laser-sharp judgments that could be more telling than multi-factor, many-sided scenarios. Although there could be many conditions for success or failure, the highlighting of one 'right or wrong' factor could be decisive, e.g. a breakthrough to product dominance on a long life profit cycle or a shattering fall into obsolescence.

Impact analysis is also crucial. Clarity is necessary here for a disciplined analysis of three points. First, on *what exactly* does the impact fall? Is it (as the outline of procedure below will identify) a key success factor or more than one such factor, and if so, which one(s)? Is it time to market? Is it brand reputation or professionals' recommendation? Is it the most powerful cost-reducer for users? Second, what is the timing and weight of the impact within the time frame chosen for the scenarios (or for the project's time line for which, in that case, the scenarios are developed)?

Thirdly, be clear what 'impact' means independently of the way the business would respond if it knew for certain it would happen and was adequately prepared to manage it. In this event, would the impact be favourable, e.g. a marketing opportunity, a technological advance, a cost-reducer? Or unfavourable – or more favourable to competitors – e.g. poor demand, premature launch, heavier on cost, constrained by regulators, attacked by media, etc.? Or a pressure or a need to be met by the business – that is, what gap would be exposed and have to be closed (by some action not yet specified)?

The impact is not to be described in terms of what would be the response, i.e. the action plan, but what kind of need would have to be satisfied, e.g. 'in those conditions, production would have to be much bigger to spread unit costs', or 'much greater skill would be needed for sales in countries X, Y, Z.' Whatever the judgments, and there may be several impacts on one and the same key success factor, this approach deals with threats and opportunities, and the more precise the judgment the better the assessment. Assuming that a product development investment is under consideration, the impact of different scenarios should concentrate minds on questions such as whether the requirements for success are the same or different, and whether the key success factors are the same or different.

In consequence, what are the upsides and the downsides of each set of impacts? What is the relation between risk and gain? How many different combinations of risk and gain are to be assessed? Ultimately, there is the question as to the broader and longer time value of each strategy – and that moves the analysis into the orbit of Real Options analysis, as will be illustrated. The foregoing sketch of what scenario analysis involves is summarised by marking out its essential procedural steps. In Figure 3 they are described with particular reference to questions typically asked about the value of transforming an investment programme into a certain product or family of products.

The key points at which the companies in the two cases conformed or failed to conform with scenario best practice will be reviewed. In view of the focus of attention in this paper, the primary emphasis will be upon steps 4 and 5.

1. Determine the goal of the project. Qualitative perhaps initially, and then subsequently quantitative. Serial scenarios may be developed: a set for each different goal, should there be more than one goal.
2. To achieve the defined goal, what are the key success factors – what must the business be especially good at: its outstanding competences and methods.
3. Build a minimum of two different scenarios, where different could at first mean 'opposite' but others may be developed out of different factors in the external environment, e.g. a competitor future, a consumer or end-user future, a localisation versus globalisation future development.
4. Analyse the impact each scenario could have on the relevant key success factors, preferably by highlighting the key success factor that emerges as crucial, e.g. 'We are so far advanced that no competitor could catch up with us for five years' and its contrary, if yielded, by a different scenario.
5. In terms of impact, what are the judgments now as to 'go' or 'no go'? Important check: can the goal originally set in 1 be achieved given the impacts under any of the scenarios – can that loop be closed? Or are there now emerging scenarios whose impacts suggest not proceeding with the project, or delaying it, or waiting, or tying it to other projects – or changing the original goal or the time scale? At which points the questions lead into the network of choices constituting the territory of Real Options analysis.

Figure 3: Five key scenario steps

Although scenarios and Real Options analysis are both tools for dealing with uncertainty that can be used to compliment one another, there is no evidence that they have been combined in management practice, although Miller and Waller (2003) have proposed combining the two approaches in the following three step integrated risk management process.

The merit of this integrated approach to risk is appealing: while scenario planning turns managers' attention toward the external environment, an assessment of potential Real Options available provides an effective tool to evaluate the possible responses to create value under uncertainty. Furthermore, beyond this role, Real Options analysis can be quantitatively robust and

Step one To create scenario 'plots' of future states of the business, where managers identify where each business is exposed to three levels of environmental contingencies:

- General uncertainties (macroeconomic, social, political, natural).
- Industry uncertainties (market, product, competition, technological discontinuities).
- Company uncertainties (operations, credit, R&D, liability, human capital).

Step two To identify exposures and the relative investment options to maximise the value or hedge risk.

Step three To evaluate investment alternatives using Real Options analysis.

Figure 4: Integrated risk management process

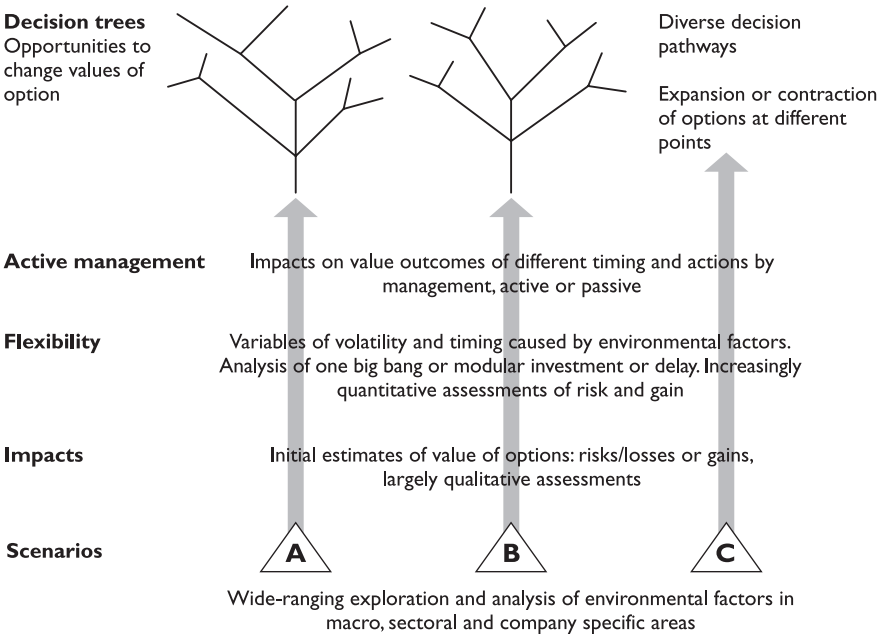


Figure 5: Linkage of Real Options with scenarios

its application, not only its underlying logic, can be achieved by practising managers.

The authors also propose an integrated approach illustrated in Figure 5 that shows the linkage between scenario thinking and Real Options analysis. At the base is the development of robust scenarios, which are critical to ensure that relevant Real Options analysis is undertaken. To illustrate this integrated approach, two business cases will be used related to research and development (R&D) investments in the pharmaceutical industry. Pharmaceutical R&D is an ideal field for demonstrating the application of Real Options, because in this industry value is maximised by a series of discrete stop/go decisions on product development. Moreover, the discontinuities in clinical research can create significant volatility in the value of project assets. Furthermore, the authors had the unique opportunity to draw upon two examples in which there was personal involvement, the ability to implement the resulting investment decisions and to measure their outcomes.

The intricacies of dealing with uncertainty will be discussed with the aim of understanding retrospectively the potential benefits of integrating scenarios with Real Options analysis. Both cases date back nearly a decade: at that time they probably represented the forefront of decision making. Their use is a significant advantage, because it means that there is the luxury of being able to reflect upon processes and the outcomes from a distance: the managerial lessons learned from those cases will be used to generate a useful discussion on the benefits of integrating strategic and financial risk assessment into a unique management process.

Valuing an expansion strategy: the Eli Lilly case (Micalizzi and Favato, 1999)

Overview

In 1994, Eli Lilly & Co. was negotiating with a biotechnology research company the marketing rights for a new compound, REOPRO® indicated for the treatment of restenosis of coronary arteries after the intervention of percutaneous transluminal coronary angioplasty (PTCA). Coronary artery disease is the narrowing or obstruction of the blood vessels caused by fatty deposits. Angioplasty, a common non-invasive procedure, reshapes the blood vessel, opening the occluded artery with a balloon catheter. In some patients, re-narrowing (restenosis) may occur a few days after the PTCA. Controlled clinical studies showed that REOPRO® was effective in reducing the risk of restenosis after transluminal catheterisation (AHA, 2003).

Preliminary studies suggested potential future indications also in the treatment of unstable angina, a cardiac spasm at rest resulted in fatty deposits by build-ups narrowing coronary arteries and, at a later date, of acute myocardial infarction (AMI), commonly known as a heart attack. Initial evaluation of the approved indication (restenosis) seemed clearly to indicate a negative NPV value. The NPV projection for the three indications, considered separately, was really discouraging:

• Base case indication (PTCA)	NPV = $ –111m
• First expansion (angina)	NPV = $ –1,118m
• Second expansion (cardiac infarction)	NPV = $ –730m

According to Eli Lilly management, the forecast of future patients suitable for PTCA was highly uncertain. Subsequent extensions would depend on the PTCA performance of REOPRO®. The overall assessment should account for the possibility of expanding the marketing of the drug into related indications (angina and AMI). By purchasing the marketing and development rights of REOPRO® and launching it on the market, Eli Lilly was clearly acquiring a future option at the same time, but important questions still needed to be answered:

- Should angina and AMI treatments be developed in parallel (independently) or in sequence (staging the investment)?
- What is the total value of the investment opportunity when management can choose the optimal situation between the available expansion strategies within the next two years?
- How is the value of synergy and the opportunity affected if the AMI is less correlated with angina?
- What is the total value breakdown?
- Which input variables have the most significant impact on total value?

It is important to note that the basic scenario plots identified by Eli Lilly management focused exclusively on one dimension, which was the future

positive clinical effects of the product, failing even to consider alternative scenarios determined by competitive pressures. It was known at the time that Merck was in the late stage clinical development of a similar drug (AGGRASTAT®) and Schering Plough was considering acquiring the marketing rights of INTEGRILIN®, an anticlotting agent with features very similar to REOPRO®.

The basic scenarios envisaged by Eli Lilly completely ignored the possible likelihood and turbulences generated by future, but very close, competitive pressures. This short-sighted approach to a complex investment decision proved to be very costly to Eli Lilly: the use of a broader integrated approach to risk management would have identified earlier the potential risk, probably leading management to take a different position about the investment risk embedded in the REOPRO® investment decision. In retrospect, widening the content for possible scenarios should have been a part of the analysis undertaken by Eli Lilly. Attempting scenarios does not, of course, guarantee that all relevant opportunities and threats will be on the radar screen, but narrowness of vision is diminished and potential disasters may be avoided.

What were the options?

Managers and investors who understand the value of available options will gain the greatest insight into true business potential but undoubtedly, the initial hurdle was to identify the right options (Trigeorgis, 2005). Real Options thinking highlights the point that management intervention – call it 'strategic action' – often creates valuable options. Once identified, these options can be assessed and exercised (if appropriate), starting the cycle of value creation and new options all over again. The approach adopted by the authors was to assess the options available to Eli Lilly in terms of flexibility, contingency and volatility. As will be illustrated in the Eli Lilly case, all three were highly relevant. What is meant by them?

- Flexibility is the ability to defer, abandon or expand an investment. Within the next two years Eli Lilly's management could have decided to exercise an expansion option, paid the necessary development costs then and proceeded to the drug's extension to other applications.
- Contingency here means future investments are contingent on something happening in the future. Managers can make investments today, even in those presently showing a negative NPV value; to access future much higher NPV investment opportunities from deterministic budgeting models often inadequately capture these. Building on the experience with REOPRO® in a low risk therapeutic segment such as PTCA, Eli Lilly researchers could have expanded the clinical development to two more competitive sectors, such as angina and acute myocardial infarction, significantly reducing the cost of entry.
- Volatility is a factor that somewhat counter intuitively increases the value of options. In option theory, higher volatility – because of the asymmetric payoff schemes – leads to higher option value. For example, the uncertainty related to the actual number of patients eligible for REOPRO®

treatment after PTCA procedure would increase the value captured by the NPV initial projections.

In the Eli Lilly case the main value drivers in the uncertainty of the number of PTCA patients (main risk driver) were identified as well as the upside potential enhanced by two expansion options (angina and AMI). A decision map was built specifying two options:

1. Expand into angina within the following two years, if the present value of the expanded market was higher than the development costs to obtain the product approval from FDA.[1]
2. Expand into AMI between years 2 and 4, either directly if the present value of AMI was higher than development costs, or indirectly to exploit synergies from first developing the angina treatment.

Modelling issues

The second dilemma in applying Real Options is which model to use. For REOPRO® a Real Options pricing model was developed, based on the following five Black-Scholes inputs outlined earlier:

1. **Exercise price:** This represented the present value of the estimated cost of clinical development to obtain the angina and the AMI indications ($480m).
2. **Stock price:** This represented the present value of the underlying asset or the present value of the cash flows from the project, excluding the sequential R&D investments to be made ($174 m).
3. **Time to expiration:** Project life (T) = 7 years.
4. **Project volatility:** Standard deviation of the percent changes in PTCA value (40%).
5. **Risk-free rate:** 8%.

The results of the Real Options analysis were the following:

Options	**$m**
Angina	46
AMI	88
	134
Base case NPV (PTCA)	–110
	24
Synergies	40
Value of project with synergies	**64**

Expansion options into two additional future treatments (angina and AMI) made the REOPRO® project worthwhile. $24m ($46m + $88m – $110m) and as a result of applying the Real Options model, it was evident that Eli Lilly should proceed with the acquisition of REOPRO® licensing rights and should launch the drug in the PTCA product focus. Furthermore, Eli Lilly should

[1] The value of angina option was partly depending upon the AMI option, due to the developed credibility of the drug's effectiveness established among cardiologists.

pursue a sequential rather than parallel expansion strategy to exploit the value of synergies, which would be an extra $40m.

Review

Eli Lilly decided to launch REOPRO® worldwide for the treatment of vascular restenosis secondary to PTCA, the first treatment approved by regulatory authorities, the Food and Drug Administration in USA and the Agency (EMEA) in the European Community. Shortly after its global introduction, REOPRO®'s future losses appeared to be potentially worse than anticipated by the base case NPV, driven down by a competitive decision not captured by any of the scenarios considered. Merck was about to receive marketing approval from the FDA for AGGRASTAT®, a direct competitor at half the price of REOPRO®.

This unexpected pricing decision was not followed by Eli Lilly, thereby limiting REOPRO®'s access to patients eligible for preventive treatment of restenosis secondary to PTCA intervention. Almost at the same time, Schering Plough filed for approval of the third competitor, INTEGRILIN®, whose price was aligned to AGGRASTAT®'s cost of treatment. Concerned about the emerging multiple competitive threats, business economists were not recommending further development of the molecule. The Real Options model showed what appeared to be the best decision for REOPRO® and it clearly warned about the modest value of its expansion strategy.

However, what actually happened highlights that the soundness of Real Options thinking has a crucial dependency on the identification of relevant factors in the external business environment. The case demonstrates that it is essential for preliminary management effort to be directed at plotting scenarios, ideally identifying all relevant potential risks, not only those related to the specifics of the product decision, but also the potential threats coming from using scenarios – the 'story lines' generated by posing 'what if . . .?' questions about the future – and with a widely diverse range of possibilities. Such story lines apply not only to competitors but also to many other external factors such as distribution, communication, the law, government policy, and economic factors that impact on public and private spending.

From the Eli Lilly case, the conclusion can be drawn that the superiority of Real Options over straight NPV rests not only on its decision tree logic, but also on the ability to develop substantively relevant scenarios through which to depict alternative conditions. This second factor – a grasp of changing real conditions – is not guaranteed by the validity of the mathematics employed. What the application of Real Options revealed was the need for the greater use of scenario analysis type techniques to capture competitor analysis; this could have been used effectively within the framework to highlight deep out-of-the-money situations. In essence, the Real Options approach offers a great deal if it is combined with applied common sense to question key assumptions rather than accept deterministic outcomes. The next case provides additional insights into the importance of competitive analysis and Scenario Analysis as a critical prerequisite of a useful Real Options framework for assessing future investment decisions.

Timing to invest: the Schering Plough case study (Micalizzi and Favato, 1999)

In 1997 the leading anti-allergy medicine, CLARITYN® (loratadine) was a global blockbuster, contributing to more than 50 per cent of the profits of Schering Plough, the pharmaceutical company marketing the product. Schering Plough management was preoccupied with the upcoming expiry date of its patent: the imperative was to replace CLARITYN® with another blockbuster capable of replacing the cash flows inevitably eroded by the introduction of loratadine generic competition. The most promising candidate in the Schering Plough R&D pipeline was mometasone, a new steroid at the end of Phase II safety testing that could be clinically developed to obtain two products leading to two different treatments:

- NASONEX® – a nasal spray for the treatment of allergic rhinitis.
- ASMANEX® – an inhaled steroid for the treatment of asthma.

As Schering Plough Research Laboratories had discovered mometasone (the steroid molecule common to both products) it owned patent rights on the molecule and all its future clinical developments. The key issue was related to the cost of clinical development. The NPV of the Phase III clinical trials for ASMANEX®, including structural fixed costs, amounted to approximately $275m over a four year period. NASONEX® would have required less than one fifth of the expected ASMANEX® investment in clinical research and shorter trials, merely a few months long. In this context, the issue of irreversible investments assumed critical importance. Schering Plough might have been better off postponing the clinical development of ASMANEX®, making go-no-go decisions conditional upon the positive outcomes of the secondary value driver, NASONEX®. A project structure to evaluate the option of postponing the ASMANEX® investment was requested, valuing the cost of postponing some stages of clinical trials.

Identifying possible scenarios

Although Schering Plough was a global leader in allergy drugs, the company did not have experience and credibility in the treatment of asthma; in fact, GlaxoSmithKline (GSK) and Astra Zeneca were the main players in the market. As a consequence, Schering Plough was faced with the marketing challenge of bridging the 'cultural gap' between CLARITYN® and ASMANEX® so as to convince physicians that Schering Plough's past success and leadership in allergy was relevant in the successful penetration of the asthma market sector. As the patent of CLARITYN® was about to expire, the marketing value of a sensitively-timed investment on the first launch of mometasone in a respiratory application, even if relegated to a niche therapeutic area such as rhinitis, was critically important. In this way it would be possible to establish the necessary credibility with the medical community to successfully launch ASMANEX® at a later date.

Similarly in this case, as for REOPRO®, a thorough competitive analysis would have provided important insights to better evaluate the future revenue-

generating potential of both compounds. Schering Plough management analysis focused on the marketing strength of major global competitors, omitting to develop a perspective on future medical needs and competitive innovation. GSK and Astra Zeneca were actually developing a revolutionary treatment of asthma, based on the combination of two existing drugs: a steroid and a lung capacity expanding agent. While asthma is today recognised as a chronic inflammatory condition, requiring a daily inhaled steroid treatment to be cured, the patient often feels the need of a drug with a more immediate effect to facilitate breathing.

Adding a beta stimulant (a lung expanding agent) to the daily steroid treatment regimen would soon become the golden standard of asthma treatment. Moreover, the possibility to benefit from a combined formulation using one simple device, would greatly improve the patients' compliance to the treatment, a critically important success factor for the cure of a chronic condition like asthma. A new product, offering the quick and fast relief of a lung expander and the chronic benefit of a steroidal agent, combined in just one puff per day, would quickly make all other treatments obsolete. This is just what happened a few years later. Just as the combination treatment would be beneficial for asthma patients, the combination of scenario and Real Options analysis would have been extremely useful to managers to frame this complex R&D decision correctly!

Identifying investment options

The first issues were to define the project structure and to identify the Real Options. Not all investments have options embedded in them, and not all options, even if they do exist, have value. To assess whether the R&D investment would create valuable options that needed to be analysed and valued, three key questions had to be answered affirmatively.

1. Is the first investment a prerequisite for the later investment's expansion?
2. Does the firm have an exclusive right to the later investment? If not, does the initial investment provide the firm with sufficient competitive advantages as regards subsequent investments?
3. How sustainable are the competitive advantages? In a competitive market place, excess returns attract competitors, and competition drives out excess returns. The more sustainable the competitive advantages possessed by a firm, the greater will be the value of the options embedded in the initial investment.

Schering Plough was faced with an irreversible decision to invest in the clinical development of a new anti-asthma product, ASMANEX®: while the investment required was known, the value of the asset was uncertain. The earlier launch of NASONEX® (with the same molecule, mometasone) as ASMANEX® for the treatment of nasal congestion was estimated to result in a negative NPV, because the market for NASONEX® would be significantly smaller than that for asthma.

However, the development of NASONEX® would represent an important source of clinical information for the late stage clinical development of

ASMANEX® and from this perspective, the combined NASONEX®/ASMANEX® development could be seen as a means of increasing cost efficiency in R&D and maximising the returns on ASMANEX®. In short the option to defer the Phase III clinical development of ASMANEX® was actually dependent upon the information acquired with the research investment on NASONEX®. The following table summarises the economics of the ASMANEX®/NASONEX® clinical development and launch decision.

	NPV evaluation $m	Cost of clinical trials $m	Option Value $m
ASMANEX®	–60	237	963
NASONEX®	–15	35	–15

The total value of opportunity to invest in ASMANEX® at $963m was very much higher than the -$60m estimated as being obtainable by following a deterministic NPV approach. The difference between these two, of $1,023m, represents the value of the option to postpone the decision to invest. Clearly, the negative value of the NASONEX® NPV of -$15m was more than compensated by the value of opportunity to invest in ASMANEX®. Such a result led to the following recommendation: under uncertainty, Schering Plough should invest in NASONEX® immediately, while it should wait to invest in ASMANEX® until confident of the present value of the expected cash flows to be generated by ASMANEX®.

Case review

Schering Plough launched NASONEX® immediately and waited to invest in ASMANEX®. Today, NASONEX® is the global market leader in a niche sector (allergic rhinitis), generating annual sales in excess of $500m. ASMANEX® was developed at a later date and it was made available in a limited number of countries. In comparison with the original estimates, the actual sales potential of NASONEX® was profoundly underestimated. The long term projections estimated peak sales of $100m, but actual sales topped near the $500 million mark. By comparison, ASMANEX® never achieved the expected NPV of $1 billion. Shortly after the business case was prepared, the Food and Drug Administration (FDA) approved the new combination treatment for asthma, marketed by GSK, worldwide leader in the respiratory therapeutic sector. The uptake of the new treatment was so rapid as to make all steroid single agents, like ASMANEX® obsolete. The sudden discontinuity in the market made ASMANEX® a therapeutic option of marginal interest only.

The two major flaws in the Schering Plough option pricing model were not related to an error in calculus or inappropriate choice of the mathematical model. They were failures to recognise the intrinsic value potential of NASONEX® and to anticipate (if not predict) a discontinuity in treatment options for ASMANEX®. As with REOPRO® it was not the mathematics that was the problem, rather it was that management did not appear to make better use of scenarios, especially the rigorous testing of scenarios that would impact heavily on the pricing model.

A key task was to identify and assess the scenarios that would make pricing highly sensitive. As scenarios are not predictions but pictures of different possible future conditions or contexts, building a strategy upon only one possible future risks the exclusion of too many other possibilities for which decision makers must prepare mentally. Obviously, not each and every action plan can be implemented to cover every possible future. Nevertheless, it is the range depicted by several scenarios that provides the indispensable qualitative assessments for the testing of decisions, including ones that are highly time-sensitive, as was demonstrated in this example.

The mathematical calculations built upon such assessments are the means of expressing Real Options, but the essence is a combination of scenarios constructed from common sense, acumen, detective work, knowledge of relevant theory and imagination over what could happen in the future. An active management approach to options requires judgment and applied resourceful intelligence; the mastery of the quantitative techniques is secondary.

In terms of at least one of the three advantages previously attributed to Real Options analysis, Schering Plough should have been intensely alert to volatility. A basic sensitivity analysis showed the combined impact of volatility and discount rate on the project value. The risk free rate being constant, the higher the volatility the more appropriate would it have been to wait to invest in ASMANEX® late stage clinical development. For Schering Plough this meant that large expected cash flows would lead the company to exercise the investment opportunity, and made the postponement more expensive. By comparison, the lower and more distant from the present the cash flows generated by the project and the higher the uncertainty, the more appropriate it would have been to postpone the investment, in order to wait for new information about the relevant market variables. The value of the option to invest was proportional to volatility: other inputs being equal, a higher volatility made more valuable the option to defer the investment.

Thinking real options, making real decisions

So what are the lessons to be learned from the cases?

The reviews of the Eli Lilly and Schering Plough cases established that the application of Real Options analysis needed a searching use of scenarios through which to identify relevant developments in the external environment and their impacts on the value of options. More specifically:

- The combination of the two types of analyses constitutes an integrated decision-making process for management and it yields changes in the way management approaches strategic decisions. It makes strategy an evolutionary process, flexibly moving from one choice point to the next through time.
- Whilst scenario analysis initially focuses on the impacts of external factors that are usually beyond management's control, Real Options analysis creates a 'space' for decision-making choices. It engages management in

understanding the value consequences of different networks of choice than would be afforded by NPV analysis.
- Instead of the unilinear pathway of value determined at any given time by NPV, which fixes the mind on whether to go or not go, by contrast Real Options analysis shows there are value-improving and real-protecting points of choice created by such thinking.

Whilst there are decision tree models through which, in advance of implementing a strategy one can try to anticipate which decision will be more and which will be less positive for value, these calculations are not entirely fixed in advance. Hence 'active management' means that at every choice-point or 'node' there is an opportunity to calculate the value of each alternative strategy going forward from the next expected point in time. The decision tree therefore evolves as assessments change – because with further knowledge, the scenarios can change.

The support of scenario analyses for Real Options obliges the whole process to become intensely time sensitive. Precisely because scenarios do not come with built-in clocks, the decision maker has to make judgments as to the time lines on which different causes and effects may operate, affecting the value of the choices previously made and in prospect. This necessitates meticulous and imaginative attentiveness to the scenario-based factors that could impact on the value of choices.

What are the implications?

The application of Real Options thinking is feasible and useful without the necessity to engage in high-level and daunting mathematics; indeed, the rescue of Real Options from the rarefied heights of mathematical calculations was a key motivation for this article. However, two further interrelated points must be addressed.

1. What to do: applying the methods

Basic advice can be drawn from the cases as to how to cope with situations in which the need or opportunity for Real Options analysis arises. For practising managers, the following steps are suggested:

- For any investment or action/resource plan, build scenarios from an assessment of the macro and micro factors in the environment of the business or unit in which the key success factors may have an impact. Both the Eli Lilly and Schering Plough cases illustrated the importance of this approach, although to the best of the authors' knowledge, neither company executed it, as would have been advisable. In the Eli Lilly case, contemplating a scenario where a competitor enters the market at a reduced price would have pointed out the risk embedded in the future cash flow forecast for REOPRO®. In the Schering Plough case, envisioning innovative therapeutic options available in the near future to treat asthma would have highlighted the risk of a limited market demand for the soon

obsolescent ASMANEX®, favouring the clinical development of NASONEX® for the treatment of allergic rhinitis.

Although with hindsight one can readily spot the omissions of Eli Lilly and Schering Plough, and indeed classify them as ignoring the impacts of the obvious, the practice of systematic scenario building and impact analysis (steps 3 and 4[2]) focused strongly on key success factors (step 2) normally would emphasise the key exposures to risk, especially when they had been known from previous first- or second-hand experience or important 'war stories' of the corporate culture or industry history. Comparison of different scenario components would naturally lead to grading them according to the seriousness of risk.

- Estimate time lines, frequency or likelihood of occurrence for each of these factors, and the impact on the expected value of the choice. Do not dismiss potentially high-impact occurrences when information about them is not at hand but could be acquired, or when their occurrence is given a low probability rating. Use several different points of sensitivity to gauge the variability of the value impact in terms of timing, probability and severity of impact, initially without reference to the further consideration of the mitigation of the risks.

  The basic scenario identified by Eli Lilly focused exclusively on one dimension, the efficacy of their product, failing to consider alternative scenarios focused on competitors. It was even known that Merck was in the late stage of clinical development of a similar drug. In consequence, Eli Lilly failed to estimate the value of their REOPRO® option; the investment risk in it was therefore poorly identified. The assumptions underlying Eli Lilly's pricing model unravelled. Had Eli Lilly considered alternative scenarios, it would have found the principal one was within the realm of common sense. If it had allowed itself a more 'worst case' status in terms of timing and impact, Eli Lilly would not have valued the investment in REOPRO® sufficiently high enough to justify proceeding with it.

  This lesson is reinforced in the Schering Plough case. In the case of ASMANEX®, the introduction of a new combination treatment by GSK and Astra Zeneca was on the Schering Plough radar screen: what was heavily underestimated was its rapidity of uptake in the global marketplace and the rate of therapeutic switch in patients always considered 'satisfied' with their current treatments. Question: did Schering Plough create scenarios based on two time lines – one fast and one slow for the responses of its competitors?

  The method of five steps is repeatable for scenarios which vary in timescale and content. In fact, both drugs needed to be subjected to competitive scenarios, factoring in the behaviour of major global competitors who would be zealous in defending their territory in asthma treatment. Both against each other and any invader like Schering Plough, on one scenario they would increase their innovation and try for a knockout blow. A 'business-as-usual' scenario for them should have been considered, but was rated by Schering Plough as low in probability.

[2] See Figure 3

A useful adjunct to scenario work is to interpret the prospective actions of competitors in terms of how they would see their prospects if they were to undertake scenario analysis.

- On these matters acquire multiple sources of judgment and opinion, to expand the range of possibly relevant positive or negative factors. Map out the risk/gain proportions from moderate to extreme, without dismissing the extreme. As the Schering Plough case illustrated, the pooling, debating and comparing of alternative scenarios, as well as estimates of their impacts on different options, is indispensable to the process of considering developments that should significantly undermine the dangerous assumption of infallibility. Any Advisory Board with medical opinion leaders would doubtless have advised both Eli Lilly and Schering Plough about the possible discontinuities in the therapeutic areas where they were about to enter without a specific marketing expertise.
- Ask and answer for any option the following questions:
  1. What is the near-future value of an option bearing in mind its investment cost?
  2. What is the value of the option if it were exploited in later years, and if it could exploit synergies from developments which can be implemented before its own development?
  3. Are there any indirect advantages for the longer term investment to be gained by going for a shorter term investment even if the latter has an unfavourable NPV?

     In the Lilly case these classical Real Options guidelines for valuing options were not given much of a chance. The key questions focus on whether to invest/expand, or defer/leave options, or disinvest. But the real force of these alternative pathways will only be apparent by giving weight to and comparing alternative scenarios, which does not appear to have been undertaken in this case. Had the assumptions underlying an optimistic NPV calculation been surfaced and exposed to alternative 'what if . . .?' challenges, the unilinear approach as to whether to invest would have been abandoned and loss avoided. No amount of sophisticated mathematical calculation can fill the gap in estimating the value of different options if key scenarios are excluded, for whatever reason.

     The Schering Plough case is also a clear example of the potential synergistic effect of staged investments. The launch of NASONEX® was going to establish the presence and credibility of Schering Plough in the respiratory market, increasing the expected value of the second product developed, ASMANEX®, which had a much larger sales potential.
- Now move forward to develop a decision tree and trace the possible synergies or lack thereof which would affect the value of any option relative to other options, bearing in mind the potential value arising from delay, postponement, etc. In other words, develop a pattern of interacting options rather than by viewing each option as if it were stand alone.

  This aspect was discussed in the Lilly case, where management focused on the sequential development of three clinical indications of REOPRO®

(PTCA, angina and AMI) rather than focusing on the first approved use (PTCA). The entire project's value was depending on the full development of the molecule, while the NPV of the individual indications was actually negative. Furthermore, a key focus of the Schering case was the need to work out more than one permutation in the relationship between two products with regard to development and marketing (both speed to market and uptake).

- Conduct a check of the results at this point in terms of the three goals to be achieved by combining Real Options with scenarios, namely, flexibility, contingency and volatility. The Schering case highlighted the possibility that the assumptions made in these areas could be mistaken. How higher option value of an investment could be caused by higher volatility, a counter-intuitive movement, would be one belief to be tested in the application of Real Options thinking. Hence the cases carry a health warning against snap or once-for-all-time judgments – and show that once fixed on a strategy that could be a value loser, management will not be properly alert to such changes unless prepared to periodically check relations between its actions and real world outcomes.
- Derive a map on more than one time line which focuses on the key alternative pathways for the future, clearly labelling scenarios, their key factors and assumptions, and the time lines of these factors and their impacts. Ensure that the assessments involve not only one immediate or near-term choice, but take into account and map clearly a nexus of choices whose total value and investment cost must be weighed. In the Schering case, timing was a large factor from the start, as the company had to replace a successful drug's cash flows at high speed. The inter-relation between one drug and another in terms of investment on the one hand and earnings on the other was crucial.
- Did they make more than one map of synergies between products showing chances of favourable and unfavourable outcomes? Would they have dared to assume that the follow-on product, estimated to have a very high sales potential, would be affected by a massive 'discontinuity' caused by a competitor's product launch? The lesson is the need to keep possible scenarios, however unpalatable, in play, and to work seriously on the potential between hoped-for value and real world contingencies. Start with relatively obvious possibilities. A common error is to close down alternative scenarios and their impacts because they are pessimistic. In step 3[3], scenario building, objectivity is needed.
- On this basis determine the order of preferences among strategies. Ensure that the strategies being compared are each conceived as a series of interrelated choices whose synergetic connections could be changed by new external developments (hence scenario revision) and by management intervention in the future. At stake in the Schering case was the familiar question: do we invest now or never? Beware the 'Big Bang' decision. The lesson of the case was to break down this polarised thinking and import Real Options thinking, for example, in terms of the total value over a

[3] See Figure 3

longer time scale (but checking the assumption that such a scale would be sustainable) of flexibility, i.e. deferring a product launch and counting the cost of that within the total value reckoning.

Successive management decisions were required in both the cases discussed. Eli Lilly management stopped the clinical development of REOPRO® when the competitive pricing decisions changed the economics of the entire market of acute cardiac failures, abandoning the option to develop the molecule in the two possible additional indications when R&D costs became likely to exceed future free cash flows. Eli Lilly seemed to lose interest in the entire project, as the only approved indication of REOPRO® was confirming the disappointing yields anticipated by the Real Options analysis.

On the contrary, Schering Plough focused its marketing efforts on NASONEX®, which was clearly exceeding any anticipated sales forecast and it was becoming a valuable opportunity to generate value. The project to enter the more attractive market of asthma was abandoned, as ASMANEX® rapidly became an obsolete therapeutic option.

2. Implications for managers and management education

This paper implies that managers should no longer perceive Real Options as an arcane subject. The accessibility of the technique underpinned by scenario analysis means that the combination lends itself to 'learnability' in terms of clear statements as to the following:

- What can be achieved through the combination of scenario thinking with Real Options analysis.
- How the combination of scenarios and Real Options analysis works.
- The steps to be taken initially for scenario building.
- The subsequent steps for identifying volatility, flexibility and contingency.
- Appreciation of the difference between the NPV and Real Options with scenarios approaches.

In consequence

- Managers can choose as to how much and when in the process of analysis they will confer quantitative dimensions on their value analyses.
- Most tellingly, the whole learning process can be built on real cases, with older examples illustrating what happened and could have happened.
- Options currently under consideration in an organisation can be brought to the table for analysis in either single company or public programmes.

The most important challenge is to define the options available by correctly using scenario thinking. In the authors' experience this is a seriously neglected area and one requiring far more attention. Second, with the definition and consistency in assumptions clarified, values can be established and last, but not least, effort should be expended to understand the impact of changes in input assumptions on option values so as to ensure that the chances of making

mistaken investment decisions is minimised. Does this not all look familiar? In fact, as anyone involved in a capital budgeting decision will confirm, the steps recommended are the same; understand and map the opportunity, and only then evaluate it and test the input variables critical to its success or failure, following which the sound basis for making a decision can be made.

This paper introduces an approach to managing uncertainty that provides a tool to support management decisions without relying on the intricacies of sophisticated quantitative models. Furthermore, it introduces a certain degree of discipline into Real Options decision-making by challenging managers to develop coherent scenarios about the future and to make explicit their assumptions about the contingencies affecting Real Options. Similar analyses should be undertaken to evaluate the uncertainties affecting proposed future strategic investments, blending competitive advantages, opportunity costs and potential future. If Real Options are seen in this light, with greater emphasis being placed upon scenario thinking up front rather than an over indulgence in Real Options mathematics, greater progress might be made in their application to business opportunities!

References

AHA (2003), *Heart and Stroke Facts*, American Heart Academy publication.

Anderson, T. J. (2000), 'Real Options analysis in strategic decision making: an applied approach in a dual options framework', *Journal of Applied Management Studies*, Vol. 9, pp. 235–255.

Bain (2000), 'Survey on Real Options', *The Financial Times*, October 18.

Borison A. (2005), 'Real Option Analysis: Where are the Emperor Clothes?', *Journal of Applied Corporate Finance*, Volume 17, No. 2, pp. 17–31.

Clemons E. and Webber B. (1990), 'Strategic Information Technology Investments: Guidelines for Decision Making', *Journal of Management Information Systems*, Vol. 7, pp. 9–28.

Copeland T. E. and Antikarov, V. (2005), 'Real Options: Meeting the Georgetown Challenge', *Journal of Applied Corporate Finance*, Volume 17, No. 2, pp. 32–51.

Dixit, A. K. and Pindyck, R. S. (1995), 'The Options Approach to Capital Investment', *Harvard Business Review*, Vol. 73, No. 3, pp. 105–116.

Favato, G., Mills, R. W. and Weinstein, B. (2005), 'Real Options Taxonomies', *Henley Management College Discussion paper Series*, HDP 10.

Hayes, R. H, and Garvin, D. A. (1982), 'Managing as if Tomorrow Mattered', *Harvard Business Review*, Vol. 60, No. 3, pp. 70–79.

Kaplan, R., (1986), 'Must CIM be Justified by Faith Alone?', *Harvard Business Review*, Vol. 64, No. 2, pp. 87–95.

Micalizzi, A., *Opzioni Reali*, pp. 333–365, EGEA, SDA Bocconi.

Micalizzi A. and Favato G. (1999), 'Il caso Eli Lilly: Valutazione del Lancio di un Nuovo Prodotto', in Micalizzi, A. and Favato, G. (1999), 'Timing to Invest and Value of managerial Flexibility: the Schering Plough Case Study', in Trigeorgis, L. and Micalizzi, A., *Proceedings of the first Milan international workshop on Real Options*, EGEA, SDA Bocconi. pp. 97–126.

Miller, K. D. and Waller, G. H. (2003), 'Scenarios, Real Options and Integrated Risk Management', *Long Range Planning*, Vol. 36, pp. 93–107.

Mills, Roger W. (1995), 'Developments in the theory and practice of Capital Investments: Current Usage of Capital Investment Appraisal Techniques', *Manager Update*, Vol. 6, No. 3, pp. 34–46.

Myers, S. C. (1977), 'Determinants of Corporate Borrowing', *Journal of Financial Economics 5*, pp. 147–175.

Naj, A. (1990), 'In R&D, the Next Best Thing to a Gut Feeling', *The Wall Street Journal*, May 21.

Polakoff, J. (1990), 'Computer Integrated Manufacturing: A New look at Cost Justification', *Journal of Accountancy*, 169, pp. 24–29.

Russo, J. E, Shoemaker, J. P. H. (1989), *Decision Traps*, New York: Fireside Edition.
Sender, G. L. (1994), 'Option Analysis at Merck', *Harvard Business Review*, Vol. 72, No. 1, p. 92.
Trigeorgis, L. (2005), 'Making use of real options simple: an overview and applications in flexible/modular decision making', *The Engineering Economist*, Vol. 50, pp. 25–53.
Weinstein, B. (1995), 'The Use of Scenario Thinking', in *Developing Strategic Thought*, ed. Garratt, B., Maidenhead: McGraw Hill.

Roger Mills is Professor of Finance and Accounting, Executive Director of the Henley Centre for Value Improvement (HCVI) and a member of the School of Projects, Processes and Systems at Henley Management College. Roger held a variety of senior positions in finance and industry before entering academic and business school life. Roger has conducted research, taught and consulted in shareholder, strategic and business valuation, financial aspects of strategy, corporate performance appraisal techniques, applied corporate finance, mergers and acquisitions (financial issues), emerging market valuation and cost of capital assessment, risk analysis, principal finance and private equity and investment banking. He has been involved with major research projects including pricing of telecommunication services, merger and acquisition analysis in the UK and various projects on capital budgeting and has written or contributed to 20 books and over 140 articles on finance and accounting. In 1998 when he was on a three-year half-time secondment to Price Waterhouse as Consulting Professor of Shareholder Value his book 'The Dynamics of Shareholder Value' was published. It has been reprinted many times and was published in the Japanese language.

Roger is a Chartered Management Accountant and is a Fellow of the Chartered Institute of Management Accountants, the Institute of Chartered Secretaries and Administrators, and the Association of Corporate Treasurers. Roger has worked on assignments in numerous countries in Asia, Africa, South America, Australasia, the Middle East and Western/Central/Eastern Europe. Organizations in which he has worked include companies in financial services, telecommunications, retail manufacturing, computer, and postal services industries and not-for-profit service businesses. Roger can communicate effectively in Portuguese, Spanish and French.

Bill Weinstein is Professor of International Business, a Director of the Henley Centre for Value Improvement (HCVI) and a member of the School of Projects, Processes and Systems at Henley Management College. Previously he had been Fellow in Politics, Public Policy and Management at Balliol College, Oxford. He has also served on several stock exchange listed companies as a non-executive director or chairman, which has given him practical involvement in risk management.

As lecturer, author and consultant his dual focus has been on the impact of political, economic and social change upon businesses, and the re-development of corporate strategy and organisation in anticipation of long-term change. His experience as a consultant has ranged across virtually every business sector, from many service sectors to manufacturing in steel, chemicals, vehicles, engineering, paper and paints.

Bill's version of scenario thinking as an aid to strategy formulation has been introduced in dozens of organisations across many business sectors, including not-for-profit organisations. It provides a distinctively fast and focused version of scenario analysis, used as a prelude to formal planning and quantitative estimates. His scenario technique can also be coordinated with Roger Mills' work on valuing companies and is used as a scanning device for identifying and anticipating risks.

Giampiero Favato is a Fellow of the School of Projects, Processes and Systems and a Director of the Henley Centre for Value Improvement (HCVI) at Henley Management College. Giampiero is also Contract Professor of Pharmacoeconomics at the Graduate School of Pharmacy of the University of Milan. For over a period of nearly two decades Giampiero has had international management responsibility in the pharmaceutical industry. This was ultimately as a Director in one of the major research based pharmaceutical companies where he was leader of global teams dedicated to innovation and change.

In addition to his marketing background, he was educated in economics and finance at the Graduate School of Business of the University of Chicago, where he gained an MBA. Giampiero

was awarded a DBA by Brunel University/Henley Management College, for which his research focused on Shareholder Value Creation, Corporate Strategy and Real Options. Giampiero conducted some pioneering research using Real Option Pricing Models to evaluate pharmaceutical projects. Giampiero's current academic research interest focus is on the managerial relevance of real-option decision-making. Additionally he is conducting intensive research into predicting the cost of late-stage pharmaceutical development and optimization of stop-go decisions in pharmaceutical developments.