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VALUE CREATION THROUGH REAL OPTIONS MANAGEMENT

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Introduction

Consider the problem of planning your vacation next summer. Your travel agent tells you that there are two types of vacation packages available at the destination of your choice: "rigid" and "flexible". Under the "rigid" package you have to specify exactly the dates of your vacation. Under the "flexible" package, you can go for any seven consecutive days between May 1st and September 30th. Furthermore, the flexible package is 80% refundable. How much more would you pay for the flexible package? This is one of the innumerable questions that can be answered by real options. The main purpose of the Real Options approach to management is to explicitly recognize and estimate the value of flexibility, and to optimize decisions requiring giving up, or creating, flexibility.

A Real Options approach to management and strategic management in particular considers strategic decision making as a process aimed first at actively reducing exposition to downside risk and second at actively promoting exposition to upside opportunities. The Real Options approach to management stands at the hinge between pure finance and softer areas of decision making under risk such as project evaluation, market entry and exit, organizational restructuring and re-engineering, technology adoption, etc. The approach underlines a frame of mind and uses methodologies that appeal to a wide array of managers, thus providing a common language. Real options have applications in many areas that are central to modern corporations : market coverage and development, finance, human resources management, technology management, R&D and knowledge management, etc. The approach represents a major shift in strategic management but remains relatively unknown in spite of its adoption by firms such as Airbus, GE, Hewlett Packard, Intel, Toshiba and others.

SOME QUOTES FROM THE BUSINESS PRESS :

As is clear from the following quotes, the real-option methodology is emerging as a potentially powerful tool for the executive. However this potential will only be realized by decision makers who combine the “real option state of mind” with thorough technical skills and a good information system. The implementation of a Real Options approach could be very valuable but at the same time is a challenging task.

“Enron President and Chief Operating Officer Jeffrey K. Skilling credits real-options thinking with helping Enron transform itself from a U.S. natural-gas pipeline company into a global wheeler-dealer that trades commodities including gas, electricity, water, and, most recently, telecom bandwidth**.”**

(Business Week, June 7, 2000)

“To evaluate potential projects, they almost invariably have to resort to a theory of corporate finance called the “Capital Asset Pricing Model” (CAPM). Yet real-life managers tend not to like this model, for the simple reason that it ignores the value of real-life managers. So they might welcome some recent academic work. In the ivory tower, they are talking about ditching the CAPM for a rival, called “real-options theory”, that places managers at its very core. More fundamentally, the flaw in the CAPM is that it implicitly assumes that when firms buy new assets, they hold these passively for the life of the project. But they do not. Instead, they employ managers precisely in order to react to events as they unfold. Obviously, this managerial flexibility must be worth something. Options on “real” assets (and indeed poker bets) behave rather like options on financial assets (puts and calls on shares or currencies, say). The similarities are such that they can, at least in theory, be valued according to the same methodology. There is a snag, of course: sheer complexity. Pricing financial options is daunting, but valuing real options is harder still. Their term, unlike that of financial options, is usually open-ended or undefinable. The volatility of the underlying asset can be difficult to measure or guess, especially since it is not always clear what it is-if, for example, it is yet to be invented. How can one define the appropriate benchmark asset-class in the case of a new drug for a rare disease? And there may be additional variables to consider, such as the strategic benefit of pre-empting a rival.”

(The Economist, August 14, 2000)

MORE QUOTES FROM THE BUSINESS PRESS :

"Real options - akin to financial options but for non-financial or real assets - are handy in limiting downside risk and capturing positive opportunities. Their effectiveness, however, is subject to a number of limitations. Many companies may not appreciate the options embedded in their investments. Others lack the capabilities to value real options and use them in allocating resources. International joint ventures supposedly enhance flexibility and reduce risk while multinational networks provide the enterprise with switching options." **(Financial Times, May 9, 2000)**

"The real option approach emphasizes that many investments create important, follow-on opportunities that a company may or may not subsequently exploit. Consequently, the real option approach highlights value that is contingent on earlier investments. For instance, while a given R&D investment may have a very low or even negative net present value, it may also provide platforms for future, favorable investments. Real options bear some other similarities to financial options. For example, the value of both types of options increases with uncertainty. Further, by providing managers discretion - rights but not obligations - financial and real options can help companies limit their downside risk while also gaining access to upside opportunities in the future. However, unlike financial options, real options come into existence by the opportunities created by the company's strategic investments. Because their underlying assets do not trade in liquid markets, real options also present unique valuation challenges." **(Financial Times, May 9, 2000)**

"Exploit hidden assets and you will succeed. Neglect them and you will wind up with a collection of old nags. What kind of hidden assets do I mean? For example, the unexploited opportunities to add a new product line, expand overseas or engage in e-commerce are hidden assets that do not appear on a company's financial statements and have not yet contributed to its profits. When you buy a company, you often get these features for free. I call them "real options," an analogy to the financial options traded in Chicago. There's a big difference, though. Financial options remain valuable when held by passive investors. But owning a business is not a passive exercise. The owner has a real job to do, providing governance, managing capital and helping a business achieve its potential." **(Forbes magazine, May 29, 2000)**

"Real options analysis is based on the observation, first made more than 20 years ago, that a company evaluating an existing asset or potential investment is in much the same position as the holder of a financial option, such as those written on stocks or commodity prices. The holder of a financial put option on, say, the price of oil can exercise that option if the price rises above a pre-agreed level, but doesn't have to if the price falls. Similarly, the owner of a marginally profitable oil field has the right to exploit it if the price of oil rises, but is not obliged to do so if it doesn't. That observation leads to the assumption that the future value of such an investment can be best valued in a similar way to financial options, rather than by simply discounting the cash flows expected from it in future. In particular, option valuation takes into account the risks and rewards of future uncertainty, or volatility, which traditional discounted cash flow (DCF) models do not."

(The Wall Street Journal, Feb 22 and 24, 2000).

"Real-options analysis rewards flexibility and that's what makes it better than today's standard decision-making tool, "net present value." NPV calculates the value of a project by predicting its payouts, adjusting them for risk, and subtracting the investment outlay. But by boiling down all the possibilities for the future into a single scenario, NPV doesn't account for the ability of executives to react to new circumstancesCfor instance, spend a little up front, see how things develop, then either cancel or go full speed ahead.**"** **(Business Week, June 7, 2000)**

The Link between Real Options and finance

As a direct outgrowth of finance, the Real Options approach uses techniques and methodologies which prevail in that field. However, finance is mostly preoccupied with evaluating and pricing financial instruments, put and call options among them. As the Real Options approach percolates into various areas of management and decision making, there is a shift of emphasis from pure evaluation to decision analysis and optimization.

The origin of the Real Options approach can be traced back to the remark by Steward Myers that holding a real investment project like the construction of a plant was formally similar to holding a financial call option. A construction project involves the option, but not the obligation, to spend resources at some future time in order to obtain an asset (an operating plant) whose value is normally stochastic. The randomness of a financial option arises from the fact that the underlying asset is usually a stock, so that, at the time the option is acquired, it is not clear whether the known exercise price will be lower or higher than the still unknown stock price in the future; thus the option may never be exercised. Similarly, if the price of the projected plant's output does not evolve favorably, or if investigations reveal that operating costs would be high, then it is not worth exercising the plant construction option.

Factors affecting the value of financial and real options

Call Option on Stock	Real Option on Project
Current value of stock	(Gross) PV of expected cash flow
Exercise price	Investment cost
Time to expiration	Time until opportunity disappears
Stock value uncertaintyt rate	Project value uncertainty
Risk free interest rate	Risk free interest rates

The distinction between option evaluation and decision making is only a matter of emphasis. In fact evaluation requires solving the decision problem raised by the option: should it be exercised and when? But the distinction is important: it underlines that good decision making creates value. As we argue further below, applying the Real Options approach to decision making in organizations creates value. This approach brings the discipline of finance into other areas of corporate, public, or individual activities.

Another difference between financial options and real options arises from the nature of the uncertainty affecting the underlying asset. In the world of financial options, uncertainty is all about future stock prices; it is valuable due to the limited downside and unlimited upside fluctuations of the pay-off, fluctuations that are linked to the exogenous (outside the control of the managers) variability or volatility of the price of the underlying financial assets. In the world of real options, uncertainty has value because of the ability of executives to manage the uncertainty of projects. In a world without uncertainty, managers would not be needed. Executives add value to the firm because they actively manage change as uncertainty unfolds over time. The Real Options approach attempts to quantify that value, that is, the value of active management of uncertainty by managers.

This crucial difference in the nature of uncertainty has its counterpart in the nature of the information that needs to be used for option evaluation and management. For financial options, most of the time long and frequent data series are available about stock prices. For a real option such as the construction of a production plant, the uncertainty arises from future prices or production costs; for the vacation package mentioned earlier, it is your time availability that is uncertain. While product prices may have some similarity with stock prices, they are not usually recorded with the same accuracy, nor are they driven by the same factors. When it comes to costs evaluation or to a person's availability for vacation, both the form and the nature of the data available are fundamentally different.

There are also differences in the institutional environment characterizing the option evaluation and decision making problem.

An important one is that financial markets are often rich and dense enough that appropriate portfolios of existing traded assets can duplicate the risks associated with the asset underlying a particular option. It is under such circumstances that the celebrated Black-Scholes-Merton approach is applicable. In the case of many real options, this so-called 'spanning' assumption cannot be invoked so that other techniques, such as stochastic dynamic programming, must be used instead of the contingent claims approach prevalent in financial applications.

Although widely used in finance, techniques such as stochastic dynamic optimization are by far not specific to that field. Being used by managers and engineers as well, they often constitute a common tool and language by which real option techniques and methodologies are spreading more easily from finance into other areas.

Certainly, the technical dimension of option evaluation is important and is part of the conceptual breakthrough that was rewarded by a Nobel price. But beyond techniques, the Real Options approach is mostly a way of thinking and adjusting one's behavior accordingly:

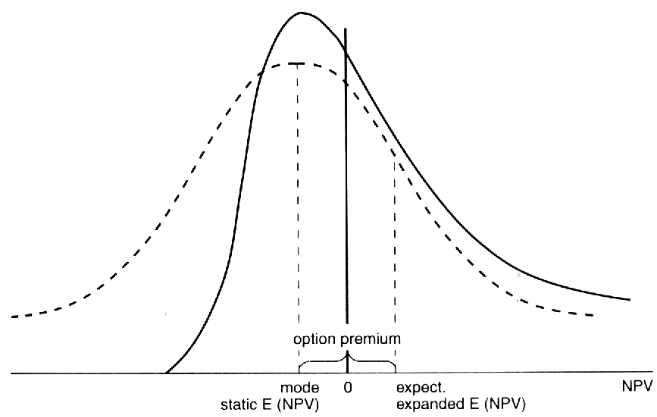
- recognition that uncertainty creates opportunities and value;
- recognition that such value requires adequate decisions in order to materialize;
- identification of the sources of uncertainty and collection of information;
- identification of the decisions (options) that promote exposition to favorable outcomes
- identification of the decisions that reduce exposure to downside risk;
- establishment of optimum decision rules.

Real Options and active management

Knowledge of real options empowers managers with the tools to calculate more accurate net present values (NPV) and thus make better strategic business decisions. One can think of calculating the *Strategic NPV* of a project defined as :

Standard static NPV
+
Option premium from active management
=
Strategic NPV

A Real Options approach helps executives quantify the value of active management. As standard static NPV calculations typically are based on the discounted value of *average* outcomes, the ability of executives to actively manage a project is not accounted for, and the static NPV will typically underestimate the true NPV of a project. Active management limits the downside and enhances the upside of the distribution of the NPV outcomes and can possibly change the expected NPV from negative to positive as the graph below illustrates. The upshot is that if the traditional static NPV approach is taken, then truly profitable projects are not implemented causing shareholder value of the firm to be less than optimal.



Project evaluation and real options

Project evaluation is the most obvious application of the Real Options approach, although by no mean the only one or the major one. Before the Real Options approach, the standard valuation procedure was discounted net present value. The Real Options approach is best seen as an improvement to conventional discounted net present value determination; it does not invalidate the procedure but amends the way it is applied. In fact it rationalizes what many evaluators are already doing on intuitive grounds:

- attach importance to the timing of decisions;
- identify and evaluate downside risks and upside opportunities associated with the project;
- identify, evaluate, and optimize future decisions that may affect exposition to downside or upside fluctuations;
- to sum up: optimally manage the creation and use of

Once these dimensions of the project are introduced, projects become proactive instruments that modify the way uncertainty affects results in the decision maker’s favor. Proper evaluation of costs and benefits always was crucial in conventional net present value evaluation. In a Real Options approach, costs and benefit evaluation becomes more difficult. Options created by the project now enter as benefits; options used up by the project enter as costs. In both cases these options must be valued and in most cases such evaluation involves finding the optimal way to decide whether and when the option must be created or used up.

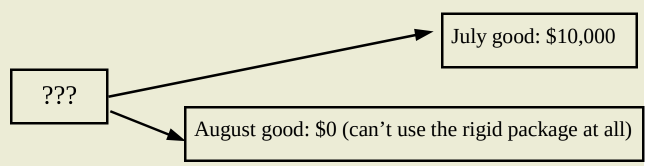
The box entitled “**Evaluation of a flexible vacation package”** illustrates the basic evaluation method of both financial and real options. Both standard textbook put option evaluations and the vacation package example are overly simplistic. Their main weakness is perhaps that they consider situations where, although valuation is an issue, the decision that confers its value to the option (sell the stock; take the trip) is obvious in each case. In most real situations the decision whether and when to exercise the option is the outcome of a complex optimization process which maximizes the value of the option.

However simple, these illustrations do demonstrate how the methodology developed for analyzing financial options can be applied to real world problems. In fact the difference between choosing a flexible flight package and an interruptible power supply scheme is not great. Of course, both the financial and the real options valuation methodologies utilize substantially richer descriptions of the uncertainty and employ more realistic assumptions. In the rest of our discussion, we mention and sometimes analyze several cases when real options have been or could be successfully applied to improve management decision-making. All of those cases are substantially more complicated than the above example. The basic underlying objective remains to optimally manage the creation and use of flexibility as a device to exploit uncertainty. This involves the following steps:

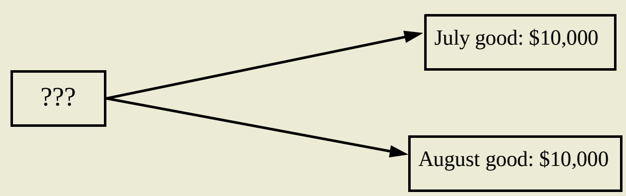
- identification of the sources of uncertainty and collection of information;
- identification of the relevant future decisions;
- construction of optimum decision rules.

Evaluation of a flexible vacation package

Your travel agent offers you two types of vacation packages to the destination of your choice: "rigid" and "flexible." Under the "rigid" package you have to specify exactly the dates of your vacation. Under the "flexible" package, you can go for any seven consecutive days between May 1st and September 30th. Furthermore, the flexible package is 80% refundable. How much more would you pay for the flexible package? To simplify the problem, imagine you know for sure you will be able to take a week off this summer, but you don’t know whether it will be in July or August. You estimate that each month has an equal probability of being convenient. Assume further that a week’s vacation to the destination is worth $10,000 more than your next best alternative (a week at the cottage). Since you don’t know which month will be convenient, you toss a coin, and you pick July for the rigid vacation. Here are the payoffs of the rigid package:



Since both July and August have equal probability of being convenient, ignoring risk, the maximum you would pay for the rigid package is $5,000 = (½ $10,000 + ½ $0).   Consider now the flexible package. It allows you to take your vacation any time this summer.   So, the payoffs to the flexible package are:



Either way, you take your vacation, so you would be willing to pay $10,000 for the flexible package. In this specific example, the value of flexibility is as big as the value of the package itself. This is not unrealistically high: a flexible fully refundable airline ticket with open dates may cost as much as ten times a rigid non-refundable ticket with fixed dates.

STRATEGIC PLANNING AND REAL OPTIONS

A good strategic plan is a plan that build real options into the foreseeable future, medium and long, of the firm and sets up an optimized decision making process to fruitfully exploit those options. Again, real options should be recognized, built in and evaluated for each major step of every project : alliances, acquisitions and mergers, spin-offs, technology development and management, organizational restructuring, etc. The value of strategic planning itself is determined by the quality of the real options designed and imbedded in the plan and by the quality of the evaluation procedure of those real options. It is in this precise sense that the design and management of real options, through the exploitation of uncertainty, create value for the firm and that they represent the most important responsibilities of the managers in determining a strategic plan.

Strategic planning is an exercise in managing flexibility. Plans should specify decision nodes, that is future steps that may or may not be taken, at dates that may be given but are mostly to be chosen optimally. Furthermore, preparing a strategic plan is not a passive exercise in anticipating the future; it is an exercise in shaping the future or, more precisely, an exercise in preparing the way, in due time, the future will unfold to the decision maker's advantage. That is, managers are planting the seeds of future flexibility by identifying and creating real options. This is again a key difference between real options and financial options: with real options, managers are creating the tool or using existing tools in highly creative ways; in the case of financial options financial executives usually pick their tools in the – sometimes highly exotic – kit of available instruments.

One important characteristic of real options in an oligopolistic environment is that they may have a negative value. As mentioned before, the value of real options derives from the active management of projects variations as uncertainty unfolds over course of a given project imply that commitment to develop and eventually complete the project is relatively low. This lack of commitment may invite more aggressive behavior from competitors whose objective may be to drive the firm out of the project or market, or more aggressive attacks from the opponents to the project. Active management means that some options should be closed while others are kept open. It is a major responsibility of high level managers to identify which options should be closed in favor of strong commitment and which options should be kept open in order to be more able to benefit from more and better information as time goes by.

REAL OPTIONS: NEW TECHNIQUES AND PROCEDURES

The Real Options approach uses all the mathematics of finance. However standard financial techniques and procedures cannot always be applied in the Real Options context. The most frequent reasons are that real risks cannot always be reproduced by market instruments so that equilibrium methods such as the Black-Scholes-Merton method are not valid; data on the underlying asset (project value) are not available in as convenient forms as financial data; the identification of available options often requires analyses that involve other fields of economics, and other disciplines in management, organization, engineering, etc..

Consequently the array of techniques and procedures involved in the Real Options approach is typically wider than in financial options. Decision tree analysis with optimized decisions at various nodes, and stochastic dynamic programming are prevalent techniques, usually applied numerically. Stochastic dynamic programming, as a mathematical tool, is much in the spirit of the Real Options approach: it seeks the maximization of a stochastic value function that can be interpreted as the value of the firm or the project, and depends on optimal decisions to be taken in the future upon the realization of events evaluation. As an optimization tool it is already widely used in such areas as inventory management, reservoir management, etc., so that a Real Options approach may be within the reach of personal with no training in finance.

Stochastic dynamic programming rely on the quality of information. The analyst must identify each step and characterize each decision in terms of its probabilistic effect on the state variables, its cost, its information content, its degree of reversibility or flexibility. Such information are usually highly project specific so that each project may require a substantial investment in data collection and analysis.

Often the analysis must go beyond data. Fully-fledged industrial analysis is warranted when decisions are truly strategic: competition, preemption, signal extraction motives, asymmetric information, etc. then become key issues. The evaluation of a new "plant" development project should yield different results, other things equal, when the new plant is explicitly considered as an addition to an existing portfolio of "plants", in the firm itself and in the industry as a whole. Similarly the evaluation of a new aircraft project involves strategic choices best addressed by real option evaluations.

Another important tool of the Real Options approach is simulation. For example, with adequate data on past demand or on past water replenishment rates, one can generate fictive samples of possible future demand trajectories or water levels. A promising new technique first developed for financial applications (Longstaff, F. and E. S. Schwartz, "Valuing American Options by Simulation: A Simple Least-Squares Approach", mimeo, UCLA, 1998.) and adapted to real situations at CIRANO consists in doing econometric inference from such fictive samples.

A more elaborate illustration

The following integrated example of a specific manufacturing problem involves several real options that are identified and described briefly in the foregoing section. The boxes provide more detailed analyses for the interested reader.

Manufacturing companies often have the option to produce some of the energy they need. In the example discussed now a firm faces a choice between three industrial boilers to generate steam. The first boiler burns natural gas, the second burns No. 2 fuel oil, and the third can be switched between the two inputs.

The first two boilers illustrate the traditional trade off between operating costs and acquisition cost. Whether or not one dominates the other depends on future fuel prices. Evaluating and comparing them for immediate acquisition requires forecasting future input prices but does not require investigating any particular future decision: once acquired, there is only one way to operate either technology.

The value of technological flexibility: the fuel switching option. The third boiler involves additional flexibility. As the first two, its value depends on future fuel prices; but in addition its value depends on the rule that will be used for switching between fuels in the future; that rule must be optimized and its proper choice confers value to the technology. In contrast with the acquisition of either one of the first two technologies, acquiring the flexible technology creates the option to switch between fuels in the future according to future fuel prices. Since future fuel prices are not currently known, future switching dates cannot be built into the project for evaluation. However the rule determining switching may be selected and the expected value of owning the boiler, conditional on that rule being used in the future, may be determined.

The value of waiting: the timing option. While acquiring one of the first two technologies does not create any option, the Real Options approach applies to them nevertheless. This is because their acquisition uses up an option: before acquiring a boiler, the firm has the flexibility to buy any boiler, or to wait and see; once the boiler is purchased there is no way back. Consequently, whatever the boiler selected, its acquisition is the exercise of an option. The timing of the acquisition, together with the choice of one particular technology, need to be optimized. As with the switching option, the decision maker does not choose a date but an optimal decision rule that will be used for the choice of the acquisition date.

Combining real and financial options. A firm that owns a single fuel burner may use financial instruments to insure itself against fuel price fluctuations. For example if it owns a gas burner, it may buy a hedge that guarantees it to be able to purchase gas at some prescribed price should the spot price exceed that ceiling.

Such hedges may also be considered if the firm owns a dual-fuel burner. They would be used as an insurance against the risk of needing to incur the fuel switching cost. If such insurance is available at reasonable cost, this will affect the optimal switching rule determined in the absence of any financial instrument. The firm will be able to let the gas/oil price ratio increase to a value higher before switching to oil and vice-versa for gas.

Thus the availability of financial instruments may alter real management, just as insurance may alter management in general. This in turns affects the value of the flexible technology: the better the available contracts, the lower the value of real flexibility.

Similarly, the more flexibility, the less insurance is needed. Flexible technology, flexible organization, flexible activities, etc. are all possible substitutes for insurance combined with rigidity. Self insurance is not only the ability to withstand adverse occurrences, but also the ability to reduce their impact by

From the single machine to the plant portfolio. In the decision sequence presented above, the Real Options approach helps evaluate the value of flexibility in a boiler. The operating rule is described in a rigorous fashion, and the decision whether to invest into such a boiler is optimized.

The Real Options approach can be applied in the same spirit to decisions of a much wider scope. Acquiring a gas-fired power plant may have a different value to one utility than to another depending on the existing plant portfolio of each firm. Conventional NPV evaluation would not capture such a difference.

For example if one power plant technology is affected by climate change (hydro power) while another technology is affected by fossil fuel cost (gas-fired plant), the same plant, to be used to serve the same market will probably be worth less to a firm that already owns several plants of the same type than to a firm that does not. This is so for two reasons. The first one is the conventional reason associated with financial portfolio construction: the market value of the new plant would have a different correlation with the assets of one firm than with the assets of the other firm. The second reason, emphasized by real options, is that each firm would choose a different way to manage the new plant if it acquired it. Under conditions unfavorable to operating that plant, the firm with few similar plants could switch it off while serving demand with other equipment, while the other firm could not. The Real Options approach helps determine more precisely how this should be done and what the implications for plant and firm evaluation are.

The fuel switching option: the value of technological flexibility

When a project involves several options, each future option confers value to earlier ones. Hence the evaluation of future options must precede the evaluation of current options. We start with the fuel switching option, focusing on the following question. Suppose that the firm acquires the third boiler now; what is the value of its flexibility? What is the switching rule that confers its value to that flexibility? The answer to both questions depends on currently known parameters such as current prices, discount rate, uncertainty, as described now.

The boilers may be described by their acquisition price and their efficiency-adjusted price of fuel. The efficiency-adjusted price of fuel is the spot price of the relevant fuel times a factor that reflects the thermal efficiency of the boiler.

The price of the first boiler is $63,500 and its efficiency-adjusted price of fuel is 1469Pgaz. The price of the second boiler is $66,600 and its efficiency-adjusted price of fuel is 1408Poil. The price of the third boiler is $68,700; it has the same thermal efficiencies as the single-fuel boilers: its efficiency-adjusted price of fuel is 1469Pgaz when it burns gas and 1408Poil when it burns oil. Furthermore, there is a fixed cost S to switch fuels in any direction.

When the ratio of the price of gas over the price of fuel is higher than 1.04 (1469/1408) it is less costly to operate the oil boiler than the gas boiler, or to operate the third boiler in the oil mode rather than in the gas mode, and vice versa. In fact if the relative price of gas is sufficiently above that ratio for a long enough time, the operating cost advantage of the oil boiler over the gas boiler may offset its higher acquisition price.

What additional value does the dual-fuel technology confer to the firm? In practice the fuel price ratio typically behaves as in Figure 1: it often crosses the 1.04 value. However it is not clear that the price ratio stays on either side of 1.04 for long enough to justify incurring the fixed switching cost, nor is it clear that it ever stays far enough on either side of 1.04 for substantial cost differences to arise between the oil and the gas regimes. Intuitively the higher the switching cost S, the further the price ratio must move away from the critical 1.04 value, and the longer it needs to stay far away from 1.04, for a switch to be warranted.

A formal analysis gives a precise content to that intuition: as shown in Figure 1, there are two critical values of the price ratio. One of them, Pg, governs switches from oil to gas; it is lower than 1.04 and lies further away from that value, the higher the switching cost. The other critical value of the price ratio, Pp, governs switches from gas to oil; it is higher than 1.04 and lies further away from that value, the higher the switching cost. Not surprisingly for users of the real options approach, the two trigger price ratios move further away from the 1.04 value as uncertainty (volatility) increases.

The decision rule just described maximizes the profit derived from the dual technology. By comparing this profits with the profits achieved if the best one-fuel technology at the current price ratio is used instead of the dual-fuel technology, one can compute the additional value conferred to the firm by the dual-fuel technology. The difference is the value of the flexibility option contained in the dual-fuel technology.

Clearly, if the price ratio were constant, one of the one-fuel technologies would always be best; the value of flexibility would be zero. Generally, the higher the volatility, the higher the value of the flexibility option. As a matter of fact, flexibility is not limited to technological, operational, flexibility. Most business decisions, especially strategic decisions, involve trading resources against flexibility. The Real Options approach may help evaluate them.

Uncertainty is usually seen as depressing profits and minds. The Real Options approach emphasizes the opposite. A firm may be modeled as holding various options. As in the above example, these options take more value as uncertainty increases and so does the firm.

The timing option: when should the preferred boiler be purchased?

The analysis of the fuel switching option has established, at any time or, equivalently, at any fuel prices, the value of the ability to switch in the future. Thus a firm considering the purchase of a boiler can compare at any date the value of the flexibility option with the acquisition cost premium associated with the dual-fuel technology and decide which is best.

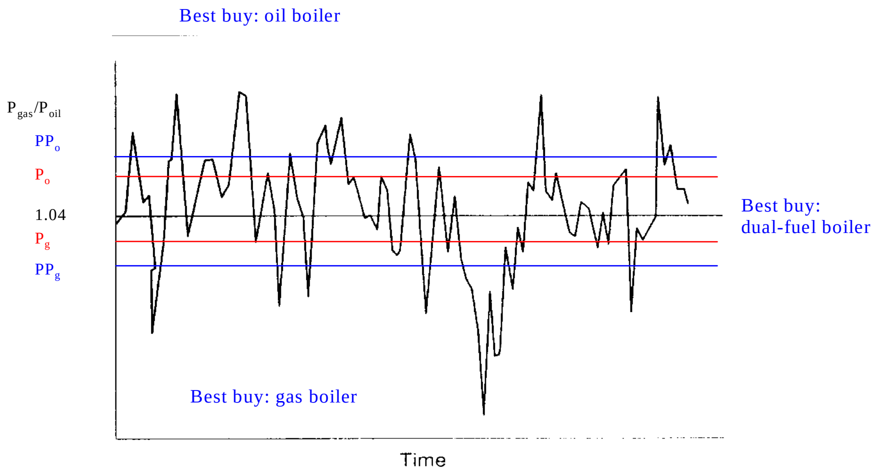
If the flexibility option is worth more than the difference between the cost of acquisition of the dual-fuel burner and the cost of acquiring the alternative one-fuel burner, it does not follow that the firm must go ahead with the investment. At any date the manager must decide whether it is time to buy, or whether it is preferable to wait in order to avoid regretting the decision in case the price ratio evolves unfavorably. Once the investment is realized it is irreversible: realizing the investment involves a loss of valuable flexibility. The foregone option to wait must be included as a cost of the project. This is where the Real Options approach again modifies the conventional NPV approach.

More contextual information is necessary to address this issue. We need to know the value of the production of the proposed boiler in order to evaluate the opportunity cost of waiting. Here the boiler allows the firm to substitute its own energy production for purchased electricity. There may be two main reasons to buy a boiler: purchased electricity is becoming more expensive; or boilers are becoming cheaper to acquire or operate.

Let us focus on the price of purchased electricity Pe. If that price is very low, it is clear that no boiler needs to be purchased. This suggests that there is a threshold price of electricity below which the manager should wait and above which the manager should go ahead with the acquisition of a boiler. In that case the analysis of the previous section indicates that the choice between the three types of boilers depend on the fuel price ratio, as indicated in Figure 1.

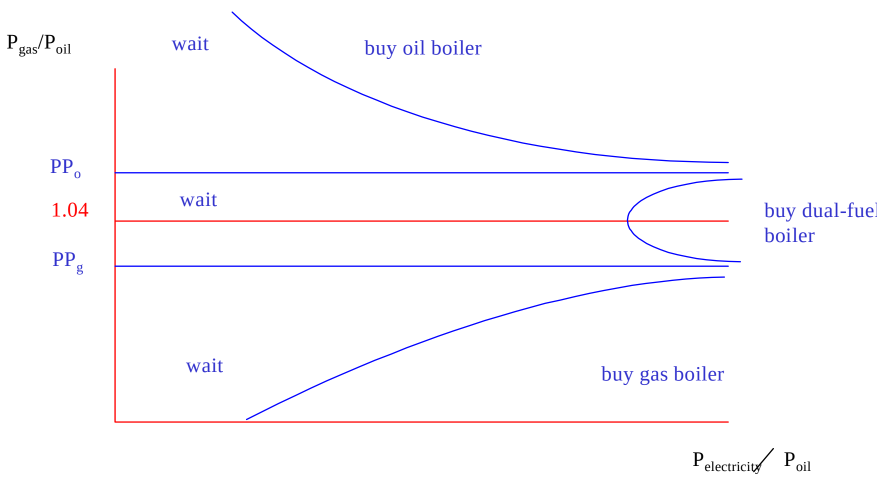
Clearly, since the dual fuel boiler is more expensive, the threshold electricity price warranting its acquisition is higher than in the case of single fuel boilers. This suggests that the threshold electricity price depends on the fuel price ratio, as drawn in Figure 2. Figure 2 is based on a conjecture that could only be confirmed and made precise through a complete Real Options analysis. The blue curve that separates the ‘wait’ domain from the ‘Buy gas boiler’ domain is upward sloping because, the closer the fuel price ratio is to the PPg value above which the dual boiler is a better buy than the gas boiler, the more likely it is that the fuel price ratio will go over the line in the future: if this happens and the manager has purchased a gas boiler, that decision will turn out to be a mistake. To protect himself against such mistake, the manager extends the waiting period by requiring a higher electricity price when the fuel price ratio is close to PPg. In fact, when the fuel price ratio is very close to PPg, the possibility of making a mistake by buying one type of boiler rather than the other is so high, that the manager prefers waiting even at high electricity prices, i.e. despite a high opportunity cost of waiting.

Figure 1. Sample History of the Price Ratio and Switching rules
The price of natural gas equals the price of No. 2 fuel oil, on an efficiency-adjusted basis, when the price ratio equals 1.04. The option to switch fuel inputs is more valuable if the efficiency-adjusted price ratio frequently crosses the point of equality.



P_o is the fuel price ratio at which the dual burner should be switched to oil when the relative price of gas is going up; P_g is the ratio at which the dual burner should be switched to gas when the relative price of gas is going down. The gap between P_o and P_g increases with the cost of switching and with volatility.

Figure 2. Boiler Buying Rule



When electricity price is low it is preferable to buy electricity rather than produce it from one's own boiler; at high electricity prices it is preferable to operate a boiler. Which boiler? Above which electricity price? When the price of gas is low relative to the price of oil, chances of buying the wrong boiler are low; thus the gas boiler should be bought at a relatively low electricity price. However, when the gas/oil price ratio is closer to PP_g, it is more likely to cross the PP_g line in the future, which would imply that the manager would prefer owning a dual boiler and would regret having acquired a gas boiler. To avoid the mistake of buying the wrong boiler, the manager requires a higher electricity price to make the irreversible decision.
Thus the line separating the "wait" locus from the "buy gas boiler" locus is upward slopping. Similarly when the gas/oil price ratio is only slighly above PP_g, buying a dual boiler might turn out to be a mistake if the ratio drops below PP_g: thus the manager cautiously requires a higher electricity price than if the gas/oil price ratio was "safely" around 1.04.

Financial Options as insurance

A financial option is the right but not the obligation to a payment in the future based on the value of an underlying asset. Financial options are hugely important securities, which allows investors to construct portfolios with virtually any desired pay-off profile, and thus enables investors to implement any view of the market--however sophisticated. Examples include Bull and Bear spreads (market will go up or down), Butterfly spreads (market will be tranquil), Straddle combinations (market will be volatile), Strips and Straps (market will be volatile but is more likely to go down than up and vice versa). A key feature of all these strategies is that the downside is limited when a long position is taken. This illustrates another key feature: Options can not only help taking speculative views in the market, they can help managing risk as well. If one is long in equity but worried about an impending stock market crash, buying out-of-the money puts is an effective and relatively cheap insurance policy.

CONCLUSION

The Real Options approach may bring the discipline and accuracy of finance into various areas of decision-making. That approach is relevant to a very large array of management and strategic decisions involving uncertainty and irreversibility. This is why many pioneer firms are starting to use it to take better advantage of a proactive type of management and create value.

Implementing a Real Options approach is not easy however. The standard procedures used in finance must often be adapted or replaced with other techniques. Each application of the Real Options approach is likely to be context specific. The available options must be envisaged and described; the relevant information must be identified and collected carefully; the executive using a Real Options approach must have the required knowledge and training to adapt standard procedures to each particular situation. Perhaps most importantly the Real Options approach is a state of mind, a capacity and willingness to detect decisions that create opportunities or protect against mishaps, and act upon them in order to create value for the firm.

For managers with such a state of mind, the Real Options approach is a tool that allows them better to bring intuition in line with the prescriptions of conventional decision-making procedures. More importantly it allows them to give a more accurate quantitative content and value to intuitive rules, thus gaining an edge over competitors.