Essay 3 – Capital Budgeting

Capital budgeting has received an increasing attention over the last ten years. Most studies have focused either on the relationships between investment decisions and financial theory, or on behavioural aspects of Capital Budgeting. The separation between analytical and organizational-behavioural aspects of budgeting, which has been criticized by many authors, appears particularly critical today: in fact, the implementation of new techniques in the analysis of investments - such as discounted cash flow modified methods, strategic options, scoring methods, analytic hierarchy process, fuzzy-logic approaches - requires an extremely accurate analysis that cannot be led only by the branch of the organization supporting the investment proposal, or by financial staffs, either. In this paper I will explore two methods (decision tree analysis and option methods) and examine how they can be used in capital budgeting.

An effective and proactive strategic management of technology involves various decisions: from the formulation of a global technology plan to the selection and the adoption of a specific new asset. The basic question regarding the latter concerns which new technology has to be adopted and when. Time, in particular, is a crucial point, and deciding on the appropriate time is a critical issue which raises substantial questions coming from: the intrinsic uncertainty surrounding each new technology; the inherently intangible nature of many of the expected benefits; the long-term perspective involved by a technological commitment; the current and future availability of technical and economic information about the new technology; the need to develop new competences and skills; the role played by learning processes; the partial or complete irreversibility of the innovative investment.

Since traditional capital budgeting techniques tend to ignore all these questions, they do not seem to be of particular help in deciding on the adoption time. Recently, however, a valuation approach which tries to overcome these limitations has emerged from the theory of financial option pricing. The resulting real option approach seems to provide a powerful tool for the assessment of technology investments because it allows one to account for irreversibility and uncertainty, and explicitly recognizes that time affects the investment returns.

The use of conventional capital budgeting techniques and, in particular, the discounted cash flow analysis in evaluating innovative projects has been widely criticized. In particular, the opinion has recently spread that, when innovative investments are concerned, traditional procedures may understate their true economic value and hence induce the firm not to pursue them. This not being the place to recall all the criticisms, we will limit ourselves to remembering that the conventional investment analysis ignores:

- the strategic growth opportunities connected with the new investment;
- the fact that the project can be discontinued before the end of its economic life;
- the possibility of delaying the investment decision;
- the arrival of information throughout the project life;
- the option temporarily to stop its execution[1].

More specifically, traditional analysis generally treats investments as isolated opportunities about which decisions must be made immediately[2] and encourages concentration on the individual decision[3]; also, having a systematic bias towards the short term, it fails to evaluate the long-term and strategic factors involved in innovative investments[4]. In short, what is important to our aims is that within this framework time is not a matter of choice, given that the investment is viewed as a now or never decision.

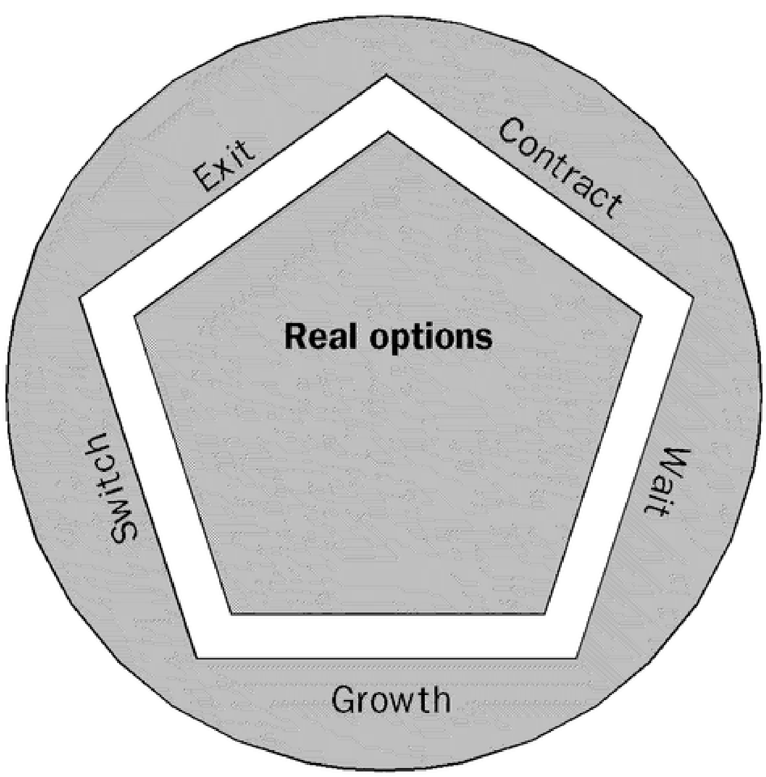
Highlighting some shortcomings of the traditional approach, in 1984 Kester[5] used the term "growth options" to denote future opportunities that (in his opinion) each investment project unfailingly carries out. Afterwards, the option concept was enriched and more often suggested

[1] Ang, J.S., Dukas, S.P. 1993, 169-86
[2] Kester, W.C., 1993, 187-207
[3] Busby, J.S. 1992
[4] Aggarwal, R., 1993, p. 9-41
[5] , Kester, 1984, 153-60

for issues such as uncertainty and flexibility, where the latter means the ease to modify a project during its execution in order to adapt it to changing business conditions. Now this conceptual device is providing several analytical and explanatory hints in the field of strategy evaluation, given that it brings out the potential of future action linked to current decisions.

With regard to the analytical procedure for giving the correct economic value to the aforementioned aspects, it simply consists in comparing them to financial options. Nevertheless, in spite of the effective logical correspondence between real and financial options, the financial methods[6] cannot be applied as they are when the former are involved. This, in fact, could require the estimation (or, better, the knowledge) of the value of market traded activities, while the project is not definitely the object of market evaluation. In addition, real investments generally involve more kinds of options at the same time (see Figure 1).

Figure 1
The various facets of a real option



[6] Brigham, E.F. 1988

There may be opportunities for deferring the investment, especially when waiting for new information means reducing risk and uncertainty. On the other hand, a delay could be the source of economic losses if competitors avail themselves of the opportunity to gain first movers advantages. When uncertainty on future (market and technology) conditions is high, the inexpensive exit from an investment which is giving unsatisfactory results may assume great value. Also, the operative flexibility of a project, i.e. possible changes during its implementation, may take on considerable economic value. Generally speaking, different kinds of real options exist:

- Growth (or incremental) options give the opportunity to benefit from subsequent investments, as in the case of modular projects. In general, they are new capabilities which can be exploited by later investments. In several cases it is impossible to define them accurately until some time has passed, after the firm has assimilated the know-how provided for the initial investment.
- Abandonment options allow exit from (or liquidation of) a project with limited expenses. They essentially depend on irreversibility; most of the investment expenditures, in fact, are sunk costs, especially when they are firm or industry specific.
- Wait options give the possibility of deferring an investment in order to acquire new and better information; the passage of time may, in fact, contribute to the resolution of uncertainty. Generally, wait options mean profiting from price reduction. In all cases, however, benefits deriving from more accurate information and price reduction go hand in hand with costs, because of delay in the investment[7].
- Options to contract allow the costless reduction of the operating scale if business conditions turn out to be unfavourable.
- Switching (or flexibility) options imply effective and not very expensive changes to the investment. In other words, switching options mean the possibility of making a different

[7] Gottardi, 13-14

use of the biggest part of the investment. Thinking about investment reversibility is very important for projects which are highly sensitive to changes in external conditions.

Returning to the assessment of these opportunities, Kester claimed that the growth option value depends on:

- The length of time the option can be exercised and the project deferred. The ability to defer decisions allows a better examination of the course of future events, thus avoiding irreparable mistakes. Hence, the longer the interval, the more likely the choice of the most propitious time to exercise the option.
- With project risk, i.e. the width of the stochastic distribution of the expected outcomes, the maximum potential gain achievable by exercising the option increases.
- The level of interest rates, since high interest rates lower the present value of future benefits.
- The exclusiveness of the owner's right to exercise the option, and hence the degree of appropriability of the project's outcomes.

Following this point of view, Kasanen and Trigeorgis[8] suggested a model which integrates an option-based approach to capital budgeting and consists in calculating the Expanded (strategic) net present value (NPV) of the investment:

$$ENPV = NPV + OP + IE$$

where:

ENPV = expanded net present value;

NPV = traditional (passive) NPV of expected cash flows;

[8] Kasanen, E. 1993, 208-3

OP = value of operating options;

IE = interaction effects (synergy, interproject dependence).

The relative importance of the three components - passive NPV, operating options and interaction effects - changes according to the conditions in which the firm acts. Certainly, the option value increases with the competitive dynamics and with the current or perspective firm's business opportunities. However, valuing these opportunities correctly is particularly complex and is further complicated by the co-existence of various kinds of options and the possible existence of options on options. With regard to the existence of joint effects between different options, it must be carefully noted that their quantification does not reduce to a simple arithmetic sum of the individual option values, since the single effects could be alternative or even annul each other.

Bearing these difficulties in mind, but thinking it correct to refer to a consolidated approach, we will develop a procedure for deciding the adoption time of a new technology on the basis of this model but now let's examine decision tree method.

Decision trees are designed to assist the decision maker with "longitudinal" decision making, where, for example, a decision may be made, some further events may occur, a subsequent decision may be necessary and yet more events may occur. They are a tool which should assist the decision maker when making an initial decision to consider the range of events and subsequent decisions that may occur or be necessary and should encourage the decision maker to think beyond the immediate decision. The series of events and decisions may occur in a relatively compressed period of time, or may be extended over a long period, of say, several years. Typically, then, decision trees may be used for forecasting. All forecasting is conducted under uncertainty, or, in other words, we do not know what will happen next!

Decision trees are constructed by a two-step process:

1. forward pass; followed by

2. backward pass.

The forward pass involves the decision maker in identifying the decisions to be made, the events that might occur and the sequence of decisions and events. The forward pass reveals the structure of the problem. During the forward pass, conditional profits must be calculated (i.e. the profits that will be achieved if certain strategies are adopted and certain events occur) and the probability of events must be assessed.

The backward pass is concerned with analysing the decision problem. Expected values are estimated by working backwards through the tree, as follows:

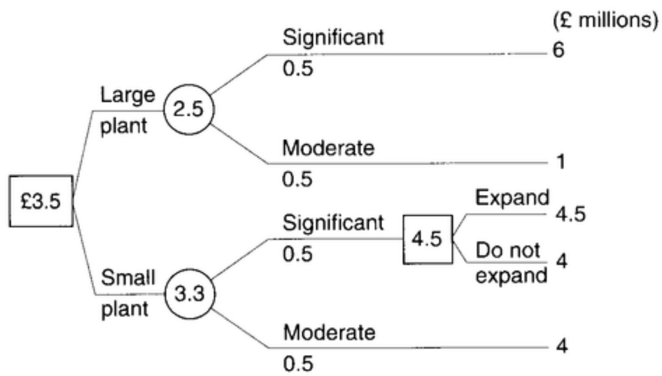
- For each set of event branches the expected value is calculated.
- For each set of decision branches the one with the highest expected value is selected.
- The strategy with the highest expected value is selected and is drawn through lines representing the other options.

The final analysis should lead to a decision. Once this decision has been identified, a preferred strategy will emerge.

A very real problem in constructing decision trees for real business decisions is the uncertainty associated with many elements of the decision model. A decision tree is supposed to cater for uncertainty of events and outcomes by considering all possible events and allocating probabilities to the likelihood of their occurring. This is far too simplistic an approach to uncertainty in the longitudinal decision-making process, because uncertainty is also embedded in the model in a number of other respects:

- There is uncertainty concerning whether all possible events, decisions and their timing have been correctly identified.
- There is uncertainty about the values of the probabilities, particularly where conditional probabilities need to be estimated.

- Different decision makers may apply different decision criteria, and thereby arrive at different outcomes.
- It can be difficult to estimate conditional profits or other values of other performance criteria.



Many of these uncertainties could be reflected in a more complex probabilistic model, but the models are likely to be sufficiently complex to deter all but the most quantitatively-minded manager.

It is at this point that many students and managers reject decision trees as having no practical application and thereby reject a very valuable tool for extending their decision-making horizons. So, of what value are decision trees?

The way forward is to recognize that decision trees are a useful way to structure the longitudinal decision-making process. Even a simple decision tree with one decision, followed by a set of events and another decision with its set of events, is a very useful model. This section explores some of the different ways in which decision trees can be used to support the decision-making process.

Payoffs

Conventionally payoffs in decision trees are displayed in the final column and often depict profit. It is important to remember that other objectives might lead to alternative payoffs. For example, in a project where cost minimization was central the payoffs might show costs, with the objective being to minimize costs. Alternatively other performance indicators associated with numbers of service encounters or quantity of stock inventory might also be used in the payoff column.

Decision criteria

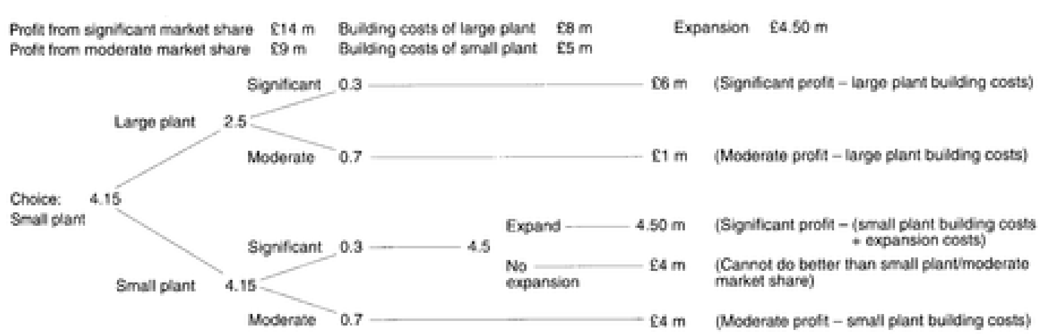
The standard approach to decision trees often uses the expected value decision criteria. It is important to recognize that this embodies a specific approach to decision making. The expected value decision criterion uses all of the information concerning the consequences of each event, and how likely each event is to occur. It does not, however, take into account the decision maker's attitude to risk. Accordingly the criterion is most appropriate when risk associated with a decision is not high.

There are several alternative decision criteria.

Equally likely criterion

This assumes that each of the potential events is equally likely. Under this assumption the possible consequences of each decision are added, and the total is divided by the total number of possible events. The strategy with the highest value is deemed to be the most desirable.

This is a sensible strategy if we have no knowledge of the relative probability of each event happening. If we do have such information, then we should use it!



Maximax

When applying the maximax strategy we look for the largest possible profit that can be achieved for each strategy, and choose the strategy with the highest potential profit. Often, in practice, but not always, this strategy also has the highest possible loss associated with it. This is regarded as a go-for-it strategy, and is not prudent. Such a strategy would only be adopted by a manager who was in a position to accept high risks. In a situation where there was no uncertainty as to which event might happen, if we knew that a specific event would happen, then we would always opt for the strategy that led to the maximum profit. Uncertainty introduces risk, which means that we might choose to be more conservative.

Minimax

The minimax criterion suggests that we choose the act with the smallest maximum possible loss, or alternatively, with the largest minimum profit. We evaluate the strategies under this criterion. Unfortunately, in practice, this criterion tends to lead to a decision to do nothin g, and leads to conservatism and stagnation. A decision which involves an element of risk is likely to have potential for greater success.

Maximum likelihood criterion

The maximum likelihood criterion leads the decision maker to choose the event that is considered to be most likely, and then to choose the best decision for that event. This approach fails to use much of the available information (i.e. that concerning the less likely events) and can therefore lead to unreasonable decisions. It is, however, a criterion often used in practice by managers when they shrink from a systematic evaluation of all possible events. They start by asking themselves what is most likely to happen, and then make their decision on the basis of this prediction. This can often provide a way forward when there is insufficient information, but it does offer a limited perspective.

The application of different decision criteria in a decision tree will often suggest:

- a different expected value at the first decision node;
- the adoption of a different strategy.

Finally, we have explored, using appropriate examples, the ways in which decision trees can be used by the manager to assist in the longitudinal decision-making process. Because of the mathematical concepts associated with complex decision trees, managers can be reluctant to attempt to use decision tree models. A recognition that such models can be simply developed in a spreadsheet environment, and can then be used for sensitivity analysis using different decision criteria, demonstrates that decision trees can offer valuable insights into the structure of a strategic decision problem. However, when the adoption of a new technology is considered, deciding on the appropriate time is an important strategic question. Time, in fact, can have a substantial influence on the competitive advantage offered by the innovation.

In this paper we have examined the value of the adoption decision, thus proposing a technique for its timing. It is a four-step procedure which substantially stands on an option-based perspective and considers adoption, not of a single decision, but a process of continuous monitoring of the business and technical environment.

The value of this approach is twofold. On the one hand, it stresses the importance of considering all the (present and future) advantages directly and indirectly involved with the new technology; on the other, it highlights the value of a persisting information-gathering activity. It is exactly in the direction of taking explicit advantage and continuously generating new opportunities that we have extended our reasoning, thus providing, from the suggested procedure, an option-based approach to technology strategy.

References:

1. Aggarwal, R., "A brief overview of capital budgeting under uncertainty", Aggarwal, R., Capital Budgeting under Uncertainty, Prentice-Hall, Englewood Cliffs, NJ, 1993, 9-41
2. Ang, J.S., Dukas, S.P., "Some implications of competition for capital investment", Aggarwal, R., Capital Budgeting under Uncertainty, Prentice-Hall, Englewood Cliffs, NJ, 1993, 169-86
3. Bierman, H., Bonini, C.P., Hansman, W.H., Quantitative Analysis for Business Decisions, 8th, Irwin, Homewood, IL, 1991.
4. Brigham, E.F., Gapenski, L.C., Financial Management. Theory and Practice, The Dryden Press, Chicago, IL, 1988.
5. Busby, J.S., The Value of Advanced Manufacturing Technology. How to Assess the Worth of Computers in Industry, Butterworth-Heinemann, Oxford, 1992
6. Curwin, R., Slater, R., Quantitative Methods for Business Decisions, Chapman & Hall, London, 1988.
7. Dixit, A.K., Pindyck, R.S., "*The options approach to capital investment*", Harvard Business Review, May-June 1995, 105-15
8. Gottardi, G., Scarso, E., "Uncertainty and `open projects'", Acts of the 6th European Forum on Cost Engineering, Milano, 13-14
9. Gregory, G., Decision Analysis, Plenum Press, New York and London, 1988.
10. Kasanen, E., Trigeorgis, L., "Flexibility, synergy, and control in strategic investment planning", Aggarwal, R., Capital Budgeting under Uncertainty, Prentice-Hall, Englewood Cliffs, NJ, 1993, 208-31
11. Kester, W.C., "Turning growth options into real assets", Aggarwal, R., Capital Budgeting under Uncertainty, Prentice-Hall, Englewood Cliffs, NJ, 1993, 187-207.
12. Kester, W.C., "Today's options for tomorrow's growth", Harvard Business Review, March-April 1984, 153-60.

13. Lucey, T., Quantitative Techniques, 4th, DP Publications, London, 1992.

14. Thirkettle, G.I., Whelden, S., Business Statistics, 9th, Pitman, London, 1991