



Real options in practice: an exploratory survey of how finance officers deal with flexibility in capital appraisal

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Dissatisfaction with discounted cash flow techniques has led to a growing literature focusing on the value of managerial flexibility in handling real asset investments, a subject area known as real options. This paper describes an exploratory survey of senior finance officers in industrial firms, examining the significance that real options assumed in their investment decisions, whether their firms had established procedures for assessing real options, and whether their intuitions were consistent with what theory prescribes.

We found that, while real options commonly occurred and were generally significant in determining how decision-makers regard an investment, there was wide variation between individual decision-makers in their perception of real options. Most respondents could recall an example of a real option with which they had dealt, and in about half the cases the option had been necessary for the associated investment to be sanctioned. Few firms have procedures to assess options in advance. Real options may not always be desirable since, in the eyes of at least some respondents, they can reduce organizational commitment to a project. Very few decision-makers seemed to be aware of real option research but, mostly, their intuitions agreed with the qualitative prescriptions of such work.

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1. Introduction

Capital budgeting has long been a subject much studied by management accounting and corporate finance academics. Discounted cash flow (DCF) methods were, and still are, a central plank in most MBA and undergraduate business programmes; students are taught project appraisal methods and the superiority of net present value (NPV) and internal rate of return (IRR) measures compared to return on investment and payback. More recently a new view, with a rapidly growing literature, has arisen out of academic misgivings about DCF techniques. These misgivings stem from the static nature of the DCF technique, at least in its basic and most commonly presented form. Briefly, this amounts to estimating the future expected net cash flows from an investment, and discounting these at the

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appropriate risk-adjusted discount rate; if this gives a positive NPV the project is accepted.

Thus the DCF method neglects the value of the flexibility of managers to react to new information as it arrives, like the value of being able to scale up a project which turns out to be more successful than expected, to close down failing activities, to wait before starting an investment, and so on. All these forms of flexibility give management the option to change the investment. This option will be exercised if it is in the interest of the firm or organization to do so. Because such forms of flexibility have many similarities to financial options (that is options on financial assets like shares, bonds or currencies), manifestations of flexibility in investments in real assets have come to be known as real options.

Real options have a fundamental effect on the normative value of capital investments. A number of studies (such as Brennan and Schwartz, 1985*a*; Paddock *et al.*, 1988; Ingersoll and Ross, 1992) have demonstrated that when an irreversible investment is contemplated in the face of uncertainty, the option to postpone the investment can be highly valuable. Other studies have suggested that the option to grow or develop explains a large component of a firm's market value (Kester, 1984, pp. 154-155). There is also evidence that having the option to abandon a project can be an important influence on the decision to adopt the project in the first place (Grinyer and Daing, 1993).

The normative theory in this field, however, is complicated and conceptually difficult. This makes it impractical as a general decision-making aid for most business managers. A natural step is therefore to assess the decision-making process in business for its recognition of the presence of options, and to determine how far this process is at least qualitatively consistent with the theory. This paper describes an exploratory survey of senior finance officers in the largest U.K. firms, assessing how, in the absence of an easily implementable normative model, firms think about real options during investment appraisal. The purpose of this survey was therefore to make an initial attempt to answer these questions. As an exploratory piece of work the aim was to develop insights rather than test firm hypotheses.

In summary we found that real options often occurred and were generally significant in determining how decision-makers regarded an investment proposal, but that there was a wide variation between individual decision-makers in attitude to real options, and wide variation in the frequency of occurrence of different types of option. Most respondents could recall at least one case of a real option with which they had had to deal, and in about half the cases the option in question had been necessary for the associated investment proposal to be sanctioned. A few firms have procedures to assess options in advance, although these normally help identify the conditions in which options are needed rather than make an explicit evaluation of the options that may be present.

Real options are not, however, always seen as being beneficial, since they reduce organizational commitment to a planned outcome or event; furthermore they may often be unavailable as a result of legislation, regulation or commercial commitments. Very few decision-makers seemed to be aware of the research in the field of real options but, mostly, their intuitions agree with the qualitative prescriptions of such work.

The layout of the paper is as follows. The next section describes the background to the issues being investigated in our survey, as reflected by the current literature

on real options. Section 3 explains the format of our survey, and Sections 4 and 5 present the results. In Section 6 we discuss some further issues that arise out of our survey, and finally in Section 7 we present our conclusions and summary.

2. Background

The large number of articles in the economics and finance literature on real options has led to several literature reviews—Stark (1990) in this journal, Pindyck (1991) and Trigeorgis (1993)—and the first two books to develop the subject in an integrated way from first principles have appeared (Dixit and Pindyck, 1994; Trigeorgis, 1996). For newcomers to this subject area there are many introductory articles, starting from the problems with DCF techniques and the consequent *raison d'être* for the real options framework; examples are Kester (1984), Myers (1984), Ashford *et al.* (1988), Barwise *et al.* (1989), the first chapter or two of Dixit and Pindyck (1994), and Dixit and Pindyck (1995).

The present paper is concerned with the role of real options in the investment decision process and it is therefore the managerial implications of real options principles that provide the most relevant background to this paper. Some of the rules for analysing real options follow easily by analogy from our knowledge of valuing financial options. In many ways the latter are easier to analyse because their terms are precisely defined; that is we know the exercise date, the exercise price and so on exactly. With real options there may well be considerable uncertainty over the value of these and other relevant variables. Nevertheless we can infer that for real options, generally speaking, the longer the life of the option, or the higher the total risk of the underlying asset (measured by the standard deviation of returns on the asset), the more valuable is the option on that asset.

These observations have some dramatic implications for the way we think about investments which involve managerial flexibility. The conventional DCF approach requires that we estimate the future net cash flows stemming from the investment and then discount these at a rate which reflects how risky the cash flows are; the higher the systematic or beta risk then the higher is the discount rate we use and so, generally, the lower is the NPV of the investment. But if there are real options embedded in the investment then this is the opposite to what the real option approach implies.¹ Any option to be flexible (for example, to expand if the project is going well, or to contract in the opposite case) is valuable, and the greater the uncertainty the more valuable the option becomes. This, of course, is precisely what intuition tells us.

Significant though this difference is, there is a potentially even more important lesson to be learnt from the difference between the DCF and option approaches. This lesson concerns the timing of the exercise of these options—that is how we decide when to expand, contract, or abandon a venture. DCF methods, at least in their most basic form, give no guidance on issues of timing; indeed the implication of a DCF calculation is to start an investment now if it has positive NPV, and otherwise not to start it, now or ever. On the other hand the real option approach

¹ Here we are glossing over the distinction between total risk and beta risk; while an increase in beta risk leads, *ceteris paribus*, to an increase in total risk, the reverse is not true. Although this is an important theoretical point, we suspect that most respondents to our questionnaire did not distinguish between these types of risk in investment valuations.

tells us when to exercise our option to start the project in terms of the value of variables like the risk and price of inputs or outputs.

Just how significant the issue of timing can be is illustrated by an example of Brennan and Schwartz (1985*a, b*) who analysed the value of a mine, assuming uncertainty over the future prices of the mineral being extracted, with fixed costs of temporarily shutting a currently producing mine if the mineral price fell, and further fixed costs of re-opening a temporarily closed mine when prices rose again. Clearly, we would expect that the greater the volatility of the mineral or the higher the fixed costs, then the greater would be the reluctance to exercise the option to close temporarily a currently operating mine in the face of a falling mineral price. There would be a similar reluctance to re-open a mine which has been temporarily closed when the price is rising.

Brennan and Schwartz (1985*b*) calculated just how far the price would have to fall before one would have to close a currently open mine, and *vice versa*, for the case of a gold mine. Using hypothetical but plausible values for the fixed and variable costs of operating mines they found, if the variable cost of gold production was \$250 per ounce, the market price had to fall to \$230 before it was optimal to close, while the price had to rise as far as \$380 before it was optimal to re-open. Of course these numbers are dependent on the inputs; but given that the values chosen were plausible, the surprising conclusion is the wide range between \$230 and \$380.² Within this range of \$230 to \$380, whether or not a mine is open or closed will depend therefore on the previous price path of gold. This phenomenon, known as *hysteresis*, is typical of a wide variety of investment situations where there are fixed costs of entry and exit together with variable costs and uncertainty of the output price. Dixit (1989) provides a general discussion of such situations.

A potentially important implication of hysteresis noted by, among others, Stark (1990, pp. 174–176), is that it may throw light on what has been described as managerial myopia or short-termism. This is managers' apparent reluctance to embark on capital investments until they are well beyond the break-even level. Another presumed manifestation of short-termism is the use in DCF calculations of a much higher discount rate than the cost of capital that would be predicted by a risk–return relationship, such as the Capital Asset Pricing Model. We would argue, instead, that a manager's decision to wait before embarking on an investment should be seen as being rational if it is a consequence of hysteresis, and the use of artificially high discount rates as being no more than an expedient to obtain the 'correct' decision within an inappropriate DCF framework.

The discussion so far has regarded the investment decision under consideration in isolation from the behaviour of competitors. This is unrealistic; of course our decisions are often affected by those of our competitors, and their decisions by ours. Thus the analysis of real options should also have a dynamic or interactive dimension. Some informal observations on these issues were made by Kester (1984, pp. 158–160). He suggested that we notionally divide options into two categories. The first he called *proprietary*; their nature and value are unaffected by the actions of others. The second type he called *shared* options; their value will be affected by the actions of others. Thus the option to develop a new product,

² The asymmetry around \$250 of the lower price of \$230 and the upper price of \$380 is largely due to the assumptions made by Brennan and Schwartz about inflation.

unprotected by patents, is a shared option; its value may be reduced by the pre-emptive action of competitors. For a formal analysis of this type of situation we will need to bring together two disparate areas of mathematics, stochastic methods for the option valuation plus game-theory, together with the economics of competition. Research is now starting on this; see, for example, Smit and Ankum (1993).

Finally we mention a related literature which is concerned with the way in which strategic decisions are made within organizations. Important contributors to this area have been Bower (1970), King (1975), the Bradford study (see for example Hickson *et al.*, 1986) and Barwise *et al.*, (1987). These studies have all been concerned primarily with the process, including behavioural and organizational issues, of strategic decision-making. While these issues were not a central strand of our project, that strategic investment decision literature is relevant to the study of real options is clearly argued by Barwise *et al.* (1987, p. 42) ‘. . . the closer we look at any *strategic* investment project the more we find that it is to a greater or lesser extent an investment in future options rather than just in one particular market opportunity’. Our questionnaire encouraged respondents to make remarks on related issues, and a number suggested organizational and behavioural constraints on the exercising of options.

It is against this setting of theoretical and academic literature that our survey sought to explore the way in which the decision-makers in industry evaluated flexibility in capital investments.

3. Method

The questionnaire was divided into four sections, each designed to explore a different issue: (i) the frequency with which respondents believed options occur in their capital expenditure projects, and the importance of options in determining how favourably the respondents treated capital expenditure proposals; (ii) the existence of organizational routines, analytical procedures and personal rules of thumb which helped assess the significance of real options during the investment decision process; (iii) the extent to which the respondents’ intuitions were consistent with the simplest, qualitative prescriptions of real options theory; (iv) the extent to which the respondents were aware of and appreciated the concepts labelled in the research and managerial literature as ‘real options’, ‘growth options’ and so forth, and their view as to the importance of having a formal tool of analysis for real options.

Each section of the questionnaire contained short descriptions to explain the points being explored. Care was taken to ensure that these explanatory descriptions did not suggest the desirability of particular responses. In order that respondents would not make an unintended connection with financial options, the ‘options’ label was avoided in all but the final section; instead we referred to ‘flexibility’. In all correspondence with the respondents we used the title ‘How important is flexibility in capital investments?’ for our questionnaire.

To assess whether the responses were affected by the type of real option under consideration, the questionnaire distinguished between the following heuristically distinct categories of options: (i) options to postpone investment (called ‘postponement’ options below); (ii) options to abandon investments once started (‘abandonment’); (iii) options to change the scale of an investment (‘rescaling’);

(iv) options to make subsequent or follow-on investments that would not otherwise have been possible ('growth'); and (v) options to change the technical nature of an investment ('technical change').

The questions required responses in three forms: (i) numerical ratings (on a five-point scale) expressing subjective estimates of quantifiable characteristics (such as frequency of occurrence of the above types of option), or reflecting intensity of agreement with assertions (such as 'the greater your uncertainty about whether conditions will make the flexibility worth exploiting, the more valuable the flexibility is'); (ii) yes-no responses to questions asking, for example, about the presence or absence of procedures to assess options; and (iii) narrative responses to open-ended questions.

The narrative items were designed both as a check on the answers to other items (for example to test whether the respondents knew terms like 'real options' had a specific meaning), and also to allow respondents to expand on further items. Since the purpose of the questionnaire was exploratory, there was a relatively large number of narrative items (18 out of a total of 47 questions). More details on the questions are given in Sections 4 and 5 below.

In addition there were a number of opportunities for the respondent to comment on the questions being posed, and the issues arising from them.

The questionnaire was sent to the Finance Directors of all firms in the FT-SE 100 index. There was no intention to draw conclusions on a wider population, and no attempt made to test for bias in the response sample. Respondents were assured that their answers would not be used in any way which revealed the identity of their company. The addressees were invited to involve colleagues in the completion of the questionnaire. Respondents were asked to state their job titles; most had a title suggesting a senior or very senior position in their firm. We received 44 completed usable replies, and 17 responses explaining why their companies were not prepared to participate in the survey.

4. Quantitative responses

Table 1 summarizes how frequently (in the respondents' judgement) real options of the five types listed in Section 3 occur in capital projects in their firms. The entry

Table 1
Frequency of occurrence of types of flexibility in capital investments (percentage responses)*

Frequency (%)	Postponement	Abandonment	Rescaling	Growth	Technical change
0-20%	21	49	30	14	43
21-40%	16	<u>28</u>	<u>23</u>	21	<u>29</u>
41-60%	<u>16</u>	9	16	12	12
61-80%	16	9	16	<u>28</u>	10
81-100%	30	5	14	26	7

*In this and the following tables, percentage responses are calculated as a proportion of those answering each question; so, rounding errors apart, each column will sum to 100.

Underlined cells represent median responses.

Table 2
Importance of flexibility in influencing investment decisions (percentage responses)

	Postponement	Abandonment	Rescaling	Growth	Technical change
Completely unimportant	9	7	5	5	5
Not especially important	37	38	23	23	40
Moderately important	<u>21</u>	<u>29</u>	<u>30</u>	<u>33</u>	<u>28</u>
Highly important	<u>26</u>	<u>23</u>	<u>37</u>	<u>37</u>	<u>26</u>
Extremely important	7	2	5	2	2

Underlined cells represent median responses.

in each cell shows the percentage of respondents saying that options of the given type occur with the stated frequency (0–20%, 21–40%, . . .). The underlined cells represent the median responses in each case. The table suggests that options to grow an investment or to postpone it are, overall, the most frequent (as measured by the 61–80% and 81–100% classes combined), while options to abandon a sanctioned investment or to make technical changes to its specification, are the least frequent (defined analogously).

Table 2 summarizes how important is the presence of each type of option in determining whether the respondent supports a proposal for capital investment. The table shows that there is little variation across the different option types: a multi-sample median test found no evidence that any of the samples came from different populations ($\chi^2 = 3.4$ with 4 df.; $p = 0.49$); further there are very few extreme responses (less than 10% of responses are at either end of the scale for any option type, and generally much less).

Table 3 summarizes the answers to a question asking subjects to assess an investment in their recent experience which embodied some type of option. The main items in this section of the questionnaire were narrative, but the table shows responses to some yes–no items asking whether the option had been *anticipated* before the associated project was sanctioned, whether the option had been *necessary* for the project to be sanctioned, whether this option actually turned out to be *available*, and whether it had been *exploited* or exercised. The large number of ‘don’t knows’ in response to the last item reflected that many of the projects selected by the respondents were still under way. Nearly all respondents (40 in 44) could recall an investment with a significant option; their answers showed that: the majority of respondents (36 in 40) could recall a project in which a real option had both been anticipated and turned out to exist; in just over half of these cases the option had been necessary for a sanction to be given; of the responses where it was

Table 3
Attributes of flexibility in investment decisions (percentage responses)

	Anticipated	Necessary	Available	Exploited
Yes	93	51	90	55
No	8	46	0	15
Do not know	0	3	10	30

Table 4
Existence of procedures within the company to assess flexibility (percentage responses)

	Postponement	Abandonment	Rescaling	Growth
Yes	20	14	43	25
No	80	86	57	75

known whether or not this option had been exercised, in most cases (22 in 28) it had been so exercised.

However the figures relating to exercise need to be treated with caution since respondents may well remember better the options which have been exercised than those which have not; all we can say for sure is that over half (at least 22 out of 40) of the options were exercised.

Table 4 summarizes the responses when subjects were asked if their firms had any form of explicit procedure or routine which called on a project proposer to make some assessment of the different option types, excluding technical change. (A further narrative item, reported below, asked about formal techniques for assessing option values.) The figures suggest that: few firms in the response sample have such procedures; where there are procedures, the rescaling options (changing the magnitude of the capital commitment either up or down) are those most often assessed, and the abandonment options are least assessed; the incidence of such procedures differs across the different types of option (pairwise cross-tabulations show each type to be significantly different from the others at the 5% level).

Table 5 summarizes the answers to a question that asked subjects to consider a capital investment (of their choice) which offered flexibility, and then decide the extent to which they agreed (on a 5-point scale ranging from 'strongly agree' to 'strongly disagree') with the following four statements about factors affecting the value of an option: the greater the cost of exploiting the flexibility when it is needed or desired, the less valuable this flexibility is (all other things being equal); the longer the period for which the flexibility will remain open, the more valuable it is (all other things being equal); the greater the uncertainty about whether conditions will make the flexibility worth exploiting, or the greater the uncertainty that it will be necessary to exploit this flexibility, the more valuable it is; the higher current interest rates are the more valuable the flexibility is (all other things being equal).

The prediction of the theoretical models would imply that the responses to each

Table 5
Agreement with statements about option value (percentage responses)

	Cost of exploitation	Time for which available	Uncertainty	Interest rate
Strongly agree	14	25	19	11
Agree	58	68	37	32
Neutral	16	2	19	34
Disagree	12	5	26	18
Strongly disagree	0	0	0	5

of these assertions should be strong or moderate agreement. In the survey the responses to the first two statements strongly conformed to this.

For the third statement, on uncertainty, only just over half were in agreement. From the academic viewpoint this failure to give stronger support was perhaps surprising in the light of the emphasis in the real option literature on the role played by uncertainty and the way increasing uncertainty increases the value of flexibility, but decreases the value of an investment without flexibility. In reality, of course, most capital investments are a mixture of real options and non-flexible investments, so the countervailing effects of an increase in uncertainty will tend to cancel each other out. This may help explain the less vigorous support for the statement on uncertainty. In addition, as we report below in the context of the narrative responses, some respondents suggest that organizational and behavioural factors may also reduce the value of flexibility; none of these effects are reflected in real option valuation models.

The responses to the statement on interest rates were more widely spread; on average they showed a very slight bias towards agreement. Given that the theory predicts only a mildly positive effect of increasing interest rates on option values, particularly at interest rate levels typical of an economy such as that of the U.K., the spread of responses to this statement is unsurprising.

We checked the results of Table 5 against the possibility that they were the outcome of random choices; the sample responses differed from neutrality with *t*-test significances as shown in Table 6.

We asked respondents whether they had heard of the terms ‘real options’, ‘growth options’ and ‘operating options’, and if so what they thought these terms meant. Only six, three and two of the respondents claimed to have heard of these terms, respectively, and the subsequent explanation they gave of their meaning suggested that in most cases they were not interpreting these labels in the sense used in the literature. We also asked respondents whether they thought a systematic method for valuing options was a real need for their firms. Two said they could not answer without further information; the remainder were exactly equally divided in their responses, with several expressing reservations which we discuss in Section 5.

Next we report on the quantifiable content of the answers to some questions which allowed respondents to describe individual experience with real options in their organization.

(1) Respondents were asked to record any types of flexibility with which they were familiar that fell outside the categories listed in Section 3. Two mentioned flexibility in financing, and two the timing of the completion of an investment. (Of course flexibility in financing is a matter of choice of capital structure, and is not a real option.)

(2) Respondents were asked to describe a sanctioned investment that embodied

Table 6
Significant differences between agreement and neutrality

Exercise cost	Maturity period	Returns uncertainty	Interest rate
$p < 0.0001$	$p < 0.0001$	$p < 0.01$	not significant

options. Of the application areas, one was in extraction plant, 13 in production plant, one in generating plant, one in treatment plant, three in service assets, six in retail and leisure facilities, two in real estate, eight in business systems and four in product development. Using our five option categories, four were abandonment options (but note the discussion of abandonment under the heading of 'Behavioural issues' in the next section), 10 were technical change options, 14 were timing options (involving the postponement or bringing forward of the project start and subsequent milestones), 16 were re-scaling options and one was a growth option. Some respondents cited more than one option but virtually all fell within our categorization.

(3) Respondents were asked whether their firms had any general methods for assessing the options associated with an investment, and whether their capital expenditure form or procedure required an identification or analysis of options which did not fit in four of the five categories used in the earlier parts of the questionnaire (postponement, abandonment, rescaling or growth). In the answers to these two questions: 16 respondents stated that sensitivity analyses were used for this assessment; three stated that the penalties for delay or non-investment were evaluated; four that investment proposals in their firms had to include a qualitative description of any associated options; four that projects were divided into phases and reviewed at milestones of the project; one that risk mitigation strategies had to be identified; two that they were currently reviewing the application of option theory to this assessment; and three had more specialized treatments (one requiring plans to react to lower product prices, one requiring the identification of cost-saving opportunities in switching between raw material suppliers, and one in using capacity forecasts to assess options).

In some of these cases the stated assessment was only indirectly connected with options and neither revealed nor evaluated specific options. In particular sensitivity analysis calculates the effect of a given change in the input variables in turn, and does not assess whether or not there is any flexibility embedded in the project. Sensitivity analysis is a technique which can be applied to any investment, irrespective of whether or not the investment involves any flexibility. Of course, by using sensitivity analysis in this way we may be able to identify the factors which are most crucial to the success of an investment; this information can perhaps then be employed to examine the project for flexibility in order to mitigate downside risk. Only a few of the respondents seemed to be making this connection.

It is noteworthy that not one respondent mentioned decision trees as a way of assessing flexibility in capital investments. An early advocate of this approach was Magee (1964), while the essential relationship between decision trees with the discount rates to be used on each branch, and the real option approach, has been described by Trigeorgis and Mason (1987).

We also asked in the questionnaire which of the following investment appraisal methods were normally used: payback, ROI (return on investment), NPV or IRR, or other (to be specified). While this question was peripheral to the main thrust of the survey it is interesting to find virtually all respondents used NPV or IRR; the figures for those using each type (out of 44) were 32 for payback (or discounted payback), 13 for ROI, and 43 for NPV or IRR. As would be expected many use more than one yardstick; a few answers mentioned alternative criteria, but seemingly only as a backup. After more than a generation of business academics

advocating the superiority of DCF measures like NPV or IRR over accounting based measures such as ROI, that message seems to have been accepted. It is therefore ironic that the academic literature is now expressing deep misgivings about DCF calculations like 'The textbook analysis that accepts all projects with positive net present values as positive is quite generally wrong' (Ingersoll and Ross, 1992, p. 1); these authors demonstrate this even when the future cash flows from the project are known with certainty, the only uncertainty being in future interest rates.

We did not ask in the questionnaire about the length of payback period used, nor about the discount rate employed to calculate the NPV. However one conjecture is that, if the payback period used is very short, then this would be a device (like the use of very high discount rates discussed in Section 2) applied simply to obtain the right hurdle in investment situations involving flexibility and hysteresis. If such situations were commonplace this could explain the high use of payback as an investment criterion which we observed, despite textbook warnings against it. However there are alternative explanations which we mention in Section 6.

5. Narrative responses

We have grouped together the more significant points arising from the narrative responses under four headings: behavioural issues, rules of thumb used to assess flexibility, need for a method to value flexibility, and lastly, general comments on the survey.

Behavioural issues

We did not explicitly refer in the questionnaire to behavioural or organizational issues so the unsolicited comments under this heading may be seen by respondents to be of particular importance.

The view that flexibility and options were beneficial qualities, *ceteris paribus*, was challenged. One respondent suggested that one aim during investment authorization was to develop a commitment, among those involved, to the planned costs and programme, and discourage the feeling that options would be available.

Several responses suggested that organizational constraints limited the extent to which options could be exercised. One respondent stated that his firm insisted on periodic reviews of a project that is under way, and at each review the project could in principle be stopped. Yet in practice the abandonment option was almost never exercised. Another respondent said that options would sometimes be incorporated in a proposal to influence waverers during the sanctioning process, with no intention on the part of the proposers that such options would ever be exercised. A third respondent said that just because an option is technically possible it is not necessarily organizationally feasible.

These points suggest an obvious general limitation of the normative theory of option value; the value of an investment depends not only on the inherent economic variables, but also on the commitment of the workforce to make the investment a success. Currently available real option models do not reflect organizational or behavioural issues, although some concerns about the possible downside to flexibility can be found in the strategy literature. For example, Das and Elango (1995) list three disadvantages to flexibility; in addition to the obvious financial reason (flexible processes usually cost more than non-flexible ones), there is also

stress for the workforce (employees may feel threatened because they have to be more versatile than when working in a regular and routine environment), and lack of organizational focus (due to the environment being in a state of flux). In addition the normally higher cost of flexible plant and machinery may give rise to fears that these extra costs will be recouped from labour saving changes, adding to unease in the organization. In a different vein, Brunsson (1990, pp. 48–49) has argued that decisions, in addition to making choices between alternatives, also serve an important motivational role; the action of taking a decision helps an organization achieve commitment in the form of coordinated, collective action from those involved in the implementation of that decision.

The earliest academic studies of real options (although not using that terminology) were specifically concerned with abandonment. Probably the first paper on this was that of Robichek and Van Horne (1969); this triggered a number of related articles on abandonment—for a recent list of references see the bibliography of Grinyer and Daing (1993). One possible explanation of the contrast between the interest of the finance or economics literature on abandonment and the apparent real-world lack of concern could be that, organizationally, abandonment is seen as defeatist, and so is not countenanced. Excluding it as a possibility can be viewed as a case of ‘burning your boats’. Another explanation is that, just as firms may introduce a new product on the back of a successful existing brand name in the belief that the perceived quality assurance of the brand name will extend across to the new line, firms may likewise be reluctant to withdraw a line because such action might be interpreted by customers as signalling problems with continuing goods.

Rules of thumb used to assess flexibility

We asked respondents to describe any rules of thumb they used to assess flexibility in managing capital investments.

The use of periodic reviews or milestones was, in one case, associated with a formal rule that if at the milestone the expenditure exceeded the target by 10%, or £1m, then the investment proposal had to be re-submitted. Although this rule is concerned with the flexibility to review the project in the event of cost overrun, it does not require a prior specification of what options there might be, only a specification of how far an uncertain variable has to deviate from expectations before options are considered.

Another personal rule of thumb cited was to ask in what circumstances a project would have a zero or negative return. Such methods are designed to obtain evidence that contradicts a proposer’s belief in a positive return to a project, and help overcome a well-known bias towards considering only evidence that confirms one’s initial beliefs. This encourages an examination of how uncertain a proposer’s predictions are, but, like sensitivity analysis, has little to do with assessing any flexibility in the project.

Further rules of thumb applied by respondents to investment options were: requiring projects with a long gestation period to have greater flexibility to react to the business environment, particularly to the actions of competitors; requiring projects to be phased in such a way that the greater the uncertainty the shorter the phase between project reviews; when investing in untried geographical territories to preserve the option to withdraw if returns turn out to be low; requiring projects with little flexibility to promise a greater return; considering what would happen if a

project fails, and having 'exit strategies' to deploy in such a case; requiring a timetable of the unfolding commitments in a project.

A number of respondents said they asked, during an appraisal, what would happen if a proposed investment were turned down, or whether it was possible to wait before investing, and what the risks of waiting would be. This suggests they have a strong intuition to keep their options open by waiting before making a commitment, provided they do not forego unacceptably high levels of operating revenues in the meantime. The emphasis here on the postponement option in the narrative responses appears to be at variance with the results of Table 2 in which the postponement option was weighted about equally with other types of option in terms of importance. On the other hand the disparity between the quantitative and narrative findings here may be due to the smaller number of narrative observations being outliers of the full quantitative sample.

Need for a method to value flexibility

Respondents were asked if they felt a real need for a systematic method to value flexibility in capital investments.

A belief in the importance of options is by no means necessarily associated with a belief in the need for a systematic method of appraising options. One respondent argued that flexibility was the key to good manufacturing investment, and that the greater the available options the easier it was to approve the investment, but yet denied the need for an appraisal method. Another similarly denied such a need, arguing that good managers incorporate flexibility in their investments as a matter of course.

There was scepticism in a third response which argued that such methods tended to be applied automatically, without thought, and therefore badly. And a fourth saw any attempt to quantify flexibility as being pointless because it was a function of so many subjective estimates. Finally, a fifth stated that it is a firm's portfolio of projects that is important in assessing its options, and that a method of assessing the options of discrete projects was of little value.

A number of respondents said that options were normally absent from their capital investments because either: the industry was regulated or subject to special legislation, and as a result had little discretion in the investments it made; or capital investments were tied to producing specialized products for one specific customer, and that the firm was therefore committed to making these investments in a predetermined manner.

Respondents from two firms in the same (narrowly defined) industry were at odds on the existence and importance of options. One stated that the firm had very little flexibility in its fixed asset investments, partly because of the actions of an industry regulator; the other stated that flexibility was not only available but essential, both to cope with changes in demand and the actions of the regulator. This suggests that some of the variation in responses to the questions might be due to personal or corporate perceptions, rather than to inherent business characteristics.

Several respondents qualified their answer to a question asking whether their firms had procedures to assess options by saying that they had, but that these were framed in terms of 'risks' and 'opportunities', or 'risk' and 'risk mitigation', rather than flexibility or options. This suggests that the real option, as a concept, makes sense to industrial decision-makers, although they would apply a different label to it.

General comments by respondents

Finally, we report some of the comments that were made to us on both the subject matter and the form of the survey.

Two respondents were evaluating the use of options theory in investment appraisal, and a further two had come across the theory, mentioning the recent text of Dixit and Pindyck (1994). Of the last two, both thought the theory was too complicated for managers in its present form, and that it had to be made more accessible if it were to be of practical use in industry. (It is easy to be sympathetic with the view that the type of analysis used by Dixit and Pindyck is too complicated for anything but the largest capital investments; however it is reasonable to argue that the real option literature may have useful general lessons for managerial decision-making.) Yet another person thought that this work was timely and that his (or her) firm was addressing the issues raised in the questionnaire at the present time.

One respondent complained about the excessive academic output on the subject of investment appraisal and academics' inability to leave the field to common sense. There are those within the academic community, like Pinches (1982), who in a similar vein have argued that too much emphasis has been placed on refining the computational aspects of investment appraisal, and not enough on understanding the overall process of investment decision-making.

6. Issues worth further study

In our survey we sought to discover the extent to which the models and conclusions of the real option literature matched the concerns and way of thinking of decision-makers in industry when facing capital investments with flexibility. Our investigation was at an exploratory level, leaving many issues unconsidered.

First, responses are specific not just to the firms but also to the positions held by the respondents, as well as to the time at which the questionnaires were completed. It may be that, at the time, the issue of flexibility was uppermost in the mind of someone currently engaged in sanctioning an option-rich capital investment, but not in the mind of one compiling annual accounts or raising finance. This availability may affect the answer to any enquiry about the importance of options, or of a method to help assess options. There are related issues about the *process* of investment decision-making, such as whether it is top-down, bottom-up, or something in between, or whether there are conflicts between project proposers and the decision-makers. In Section 2 we mentioned some of the more important studies in this area; Pinches (1982) and, more recently, Lai and Trigeorgis (1995) have reviewed the literature relating to the process of strategic investment decision-making. Although the latter refer (p. 72) to the literature concerning behavioural factors in decision-making, this does not explicitly consider capital investments entailing real options; what exactly are the behavioural or organizational considerations that led to the view expressed in response to our survey that real options may reduce organizational commitment to projects?

What effect might the *context* of the decision have on the way flexibility in capital investments is appraised? Although we repeated the survey on a small sample of

local industrialists³ with broadly similar results, the extent to which the findings of the main survey would generalize to wider samples is not clear. Are the results of our survey firm specific, or industry specific? If they vary across firms or industries, can we identify patterns? We have referred to the literature on strategic investment appraisal; might different answers to questions about process and context be obtained for investments where the real option component is paramount, that is where managerial flexibility to modify the investment in the light of evolving circumstances is most important?

Next, we conjectured (in Footnote 1) that the respondents to our questionnaire are unlikely to consciously distinguish between total and systematic or economy-wide risk when dealing with flexible capital investments. There is much evidence that, in practice, businesses use discount rates very much in excess of that which standard DCF analysis would require. As we explained at the end of Section 5, this may reflect an unconscious way of representing the value of waiting before investing; the use of higher discount rates would be consistent with employing DCF analysis to value investments with flexibility. If this is the case, then total risk is the relevant measure to use, rather than systematic risk, although it remains theoretically unsound to use DCF methods to value real options (Trigeorgis and Mason, 1987).

There are, however, alternative explanations of why enhanced discount rates may be used. Antle and Eppen (1985) have shown that, in an environment with asymmetric information and potential conflicts of interest between owners and managers who desire budgetary slack, capital rationing and underinvestment may result—equivalent to using enhanced discount rates. While the analysis of Antle and Eppen does not consider the value of any managerial control to alter an investment once made, Stark (1996) refers to work showing how their analysis may be extended to investments with real options.

In all, it would therefore be helpful to learn more about the choice in practice of the discount rates used for DCF analysis, whether they are higher for projects with larger options to postpone (what alternatives are used for abandonment, when lower discount rates would be valid), the extent to which decision-makers distinguish between total and systematic risk, and finally whether agency considerations drive the use of enhanced discount rates.

Finally, we should be aware of limitations of the questionnaire and its analysis. First, the comparability of answers like ‘completely unimportant’, ‘not especially important’ and so on, are dependent on these expressions being interpreted consistently by respondents. The results of Tables 2 and 5 are sensitive to this point. Second, subjective judgements (as in Table 1) of the frequency with which options of different types occur in capital investments depend on unbiased recall. The quality of judgement in subjective probability assessment is, of course, a matter on which there is much evidence of bias, at least in experimental settings. Third, there is inevitably some subjectivity in the way in which we have collated and interpreted some of the narrative responses in Section 5.

³ These were 20 participants in a seminar on ‘Managerial flexibility in decision-making’ held at Cranfield University for managers of local firms (both small, independent organizations and operating companies within larger groups); they were asked to complete the same questionnaire as used for the FT-SE 100 companies.

7. Conclusions

The survey suggests that real options often occur in investment projects, and are moderately important in influencing the support of decision-makers for an investment proposal. But there is a substantial variation among firms in both frequency of occurrence and importance of these options. Furthermore, whereas some decision-makers value the presence of real options, others regard options as being undesirable when seeking the commitment of an organization to a proposed plan of action.

Most decision-makers could recall an investment which had options, and more than half of these options had been exercised. Yet only half the time was the existence of these options necessary for the initial sanctioning of the investments.

Few firms had procedures either to identify or to evaluate most types of real option, although a third did require that rescaling options were assessed during the appraisal process. Generally, such procedures as firms did use were labelled 'risk' and 'risk mitigation', or 'risks and opportunities' rather than in terms of flexibility or options. Many firms use tools like sensitivity analysis to understand where their projects are most susceptible to uncertainties, although it seems that few take the further step of identifying and evaluating any options which they could exercise if needed. Some are sceptical about the possibility that options, whatever their importance, can be systematically assessed at the time a project is appraised.

Decision-makers generally agreed with theoretical predictions of what makes a real option valuable. On exercise cost and maturity period there were few who disagreed with the theoretical prediction; on uncertainty over half agreed with the prediction, and on interest rates less than half agreed.

Very few decision-makers had heard of the terms 'real options', 'growth options' or 'operating options' in the sense used in the research literature and management periodicals; however two firms were in the process of assessing the usefulness of real option theory in the investment appraisal process.

The overall low level of awareness amongst industrialists of the academic studies of real options confirms the appropriateness of our choice of an introductory and exploratory style for the questionnaire. Of course this low level of awareness does not imply that bad management decisions are being made—'... businesspeople often act smarter than they talk' (Brealey and Myers, 1991, p. 264); but nor does it rule out the possibility that investment opportunities may be missed due to the very real complexities of putting a value on flexibility.

To sum up, we conclude from this survey that real options play a significant role in investments and their appraisal, although systematic analysis of such options is uncommon, even among the largest U.K. firms. However a small number of these firms told us that they were actively studying these ideas. Firms do have rules of thumb that concern options, such as the way they determine the staging of investments to allow them to consider their options at uncertain times. But having options is not uniformly welcomed since they may interfere with the commitment of the workforce to the firm's plans. Finally behavioural and organizational considerations may prevent firms from exercising options which, in principle, are available to them.

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References

- Antle, R. and Eppen, G., 1985. Capital rationing and organizational slack in capital budgeting, *Management Science*, **31**(2), 163–174.
- Ashford, R. W., Dyson, R. G. and Hodges, S. D., 1988. The capital investment appraisal of new technology: problems, misconceptions and research directions, *Journal of Operational Research*, **39**, 637–642.
- Barwise, P., Marsh, P. and Wensley, R., 1987. Strategic investment decisions, *Research in Marketing*, **9**, 1–57.
- Barwise, P., Marsh, P. and Wensley, R., 1989. Must finance and strategy clash? *Harvard Business Review*, **67**(5), 85–89.
- Bower, J. L., 1970. *Managing the Resource Allocation Process: A Study of Corporate Planning and Investment*, Boston, MA, Harvard Business School.
- Brealey, R. A. and Myers, S. C., 1991. *Principles of Corporate Finance*, 4th edition, New York, McGraw-Hill.
- Brennan, M. J. and Schwartz, E. S., 1985a. Evaluating natural resource investments, *Journal of Business*, **58**, 135–157.
- Brennan, M. J. and Schwartz, E. S., 1985b. A new approach to evaluating natural resource investments, *Midland Corporate Finance Journal*, **3**, 37–47.
- Brunsson, N., 1990. Deciding for responsibility and legitimation: Alternative interpretations of organizational decision-making, *Accounting, Organizations and Society*, **15**(1/2), 47–59.
- Das, T. K. and Elango, B., 1995. Managing strategic flexibility: Key to effective performance, *Journal of General Management*, **20**(3), 60–75.
- Dixit, A. K., 1989. Entry and exit decisions under uncertainty, *Journal of Political Economy*, **97**, 620–638.
- Dixit, A. K. and Pindyck, R. S., 1994. *Investment under Uncertainty*, Princeton, NJ, Princeton University.
- Dixit, A. K. and Pindyck, R. S., 1995. The options approach to capital investment, *Harvard Business Review*, **73**(3), 105–115.
- Grinyer, J. R. and Daing, N. I., 1993. The use of abandonment values in capital budgeting—a research note, *Management Accounting Research*, **4**, 49–62.
- Hickson, D. J., Butler, R. J., Cray, D., Mallory, G. R. and Wilson, D. C., 1986. *Top decisions: Strategic decision-making in organizations*, Oxford, Blackwell.
- Ingersoll, J. E. and Ross, S. A., 1992. Waiting to invest: Investment and uncertainty, *Journal of Business*, **65**(1), 1–29.
- Kester, W. C., 1984. Today's options for tomorrow's growth, *Harvard Business Review*, **62**(2), 153–160.
- King, P., 1975. Is the emphasis of capital budgeting misplaced? *Journal of Business Finance and Accounting*, **2**(1), 69–82.
- Lai, V. S. and Trigeorgis, L., 1995. The strategic capital budgeting process: A review of theories and practice, in Trigeorgis, L. (ed.) *Real Options in Capital Investment: Models, Strategies, and Applications*, Westport, CT, Praeger, pp. 69–86.
- Magee, J. F., 1964. How to use decision trees in capital investment, *Harvard Business Review*, **42**(5), 79–96.
- Myers, S. C., 1984. Finance theory and financial strategy, *Interfaces*, **14**(1), 126–137.
- Paddock, J. L., Siegel, D. R. and Smith, J. L., 1988. Option valuation of claims on real assets: the case of offshore petroleum leases, *Quarterly Journal of Economics*, **103**, 479–508.
- Pinches, G. E., 1982. Myopia, capital budgeting and decision making, *Financial Management*, **11**(3), 6–19.
- Pindyck, R. S., 1991. Irreversibility, uncertainty, and investment, *Journal of Economic Literature*, **29**, 1110–1152.

- Robichek, A. A. and Van Horne, J. C., 1967. Abandonment value in capital budgeting, *Journal of Finance*, **22**, 577–590.
- Smit, H. T. J. and Ankum, L. A., 1993. A real options and game-theoretic approach to corporate investment strategy under competition, *Financial Management*, **22**, 241–250.
- Stark, A. W., 1990. Irreversibility and the capital budgeting process, *Management Accounting Research*, **1**, 167–180.
- Stark, A. W., 1996. Hurdle rates, the timing of capital expenditures and organizational issues, *Manchester Business School Research Newsletter*, **22** (June), 1–2.
- Trigeorgis, L., 1993. Real options and interactions with financial flexibility, *Financial Management*, **22**, 202–224.
- Trigeorgis, L., 1996. *Real Options: Managerial Flexibility and Strategy in Resource Allocation*, Cambridge, MA, MIT.
- Trigeorgis, L. and Mason, S. P., 1987. Valuing managerial flexibility, *Midland Corporate Finance Journal*, **5**(1), 14–21.