PRO2804 - Gestão Port

1) IMPORTÂNCIA

2) PROCESSO → REVISÕES
CF NOVOS

3) PROJETO TRAD → Prédio
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PROJETO P&D → Biodiesel
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6 SELECTING AND MANAGING AN INNOVATION PORTFOLIO

> As living and moving beings we are forced to act ... [even when] our existing knowledge does not provide a sufficient basis for a calculated mathematical expectation.
>
> John Maynard Keynes

> Our knowledge of the way things work, in Society or in Nature, comes trailing clouds of vagueness. Vast ills have followed the belief in certainty.
>
> Kenneth Arrow (Nobel Laureate in Economics)

INTRODUCTION

Any organization is likely to have a number of innovation projects running at any one time. Allocating resources between them to achieve optimum returns is always difficult, the more so when some have high levels of uncertainty. Managers face three challenges: the first is deciding which projects are intrinsically worth doing in themselves (the *valuation problem*); the second is choosing a group, or *portfolio* of them that best meets the overall needs of the organization (the *balance problem*); and the third is to retain the understanding and commitment of the people involved, especially those whose projects are rejected. Choosing and managing a portfolio is a dynamic activity because innovation projects change as they proceed and, as a result, some may have to be pushed forward, some delayed and some stopped altogether. Setting and managing the changing priorities among innovation projects is the third element of the Innovation Pentathlon.

A key difficulty in selecting the right innovation projects is that much of the information on which the decision should be based may be unknown, or at least uncertain, at the outset. A great deal of preparatory work may be needed to resolve the uncertainties, and indeed some risks may remain until very near the end of some projects. So project selection is often not a single decision made at the start of the project, but rather an interim decision followed by

Table 6.1 Some Acronyms Used in Project Selection and Portfolio Management

Acronym	Meaning
DCF	Discounted Cash Flow
DTA	Decision Tree Analysis
ECV	Expected Commercial value
IRR	Internal Rate of Return
NPV	Net Present Value
TBE	Time to Break Even
BSM	Black, Scholls, Merton

an investigation and a review – perhaps several times over – before a 'point of no return' is reached when a full commitment is made. Often companies use separate teams, or even departments, for exploring new concepts and for the more focused and disciplined activity of implementation (see Mini Case 6.7 on Richardson's knives).

Management action plays a vital role in steering a portfolio of innovation projects to success. As each project progresses and the uncertainties unravel, managers will face not only unanticipated obstacles but also unexpected opportunities. There will be upsides to exploit as well as downsides to manage. The first step in successful portfolio management is to embrace the inevitable uncertainty, and aim to turn it to advantage. This requires a flexible and open attitude backed up with some strong management disciplines, and a few simple tools. This chapter covers

- The principles of portfolio management.
- Financial valuation methods.
- Accounting for uncertainty in project valuation.
- Non-financial ways to value projects.
- Selecting and balancing a portfolio of projects.
- Management processes.
- A Main Case on Britannia Building Society.

Management, and especially financial management, is notorious for its use of obscure acronyms. Portfolio management has more than its fair share of these and we give a glossary in Table 6.1.

PRINCIPLES OF PORTFOLIO MANAGEMENT

The Need for a Process

Portfolio management is not just about making the right decisions about which projects to start. It is also about reviewing those decisions regularly, changing

them when necessary and helping staff and colleagues to understand and accept the changes. The ideas element of the Pentathlon diagram is drawn as a funnel to emphasize the fact that there should always be more ideas available than are finally used. The more novel ones may require some work before it is possible to make a decision, and inevitably this work will sometimes turn out to be wasted. Many companies find it difficult to accept this; but any organization that is not prepared to invest adequately in the early process of investigation and risk removal either will produce only trivial innovations or, worse, will have to cancel many projects later on when far more money has been invested. 'Fail soon to succeed quicker' is a good motto, used by the product design consultancy, Ideo. Stopping projects is often painful because people have invested much energy, enthusiasm and even their personal credibility in them, so it is very helpful to have a clear and objective process for making these difficult selection decisions.[1] The process should aim to ensure that all the key issues are understood and debated. It should encourage clarity, and where possible quantification, but at the same time allow scope for the exercise of management judgement.

An inadequate portfolio management process leads to slow decisions, a tendency to choose only low-impact 'me-too' projects and a failure to stop projects that have lost their way. The typical results of these are summarized in Table 6.2.

Portfolio management is a complex and multifaceted task. Management judgement is required but appropriate tools also help. In selecting the tools to use it is vital to remember that their role is to help managers come quickly to decisions that are not only good but can also be justified and communicated. Mini Case 6.1 describes how the World Bank redesigned its selection process to achieve these aims.

Table 6.2 Business Impact of Poor Project Selection Processes

Management Issue	Resulting Problems
Slow decision-making	• Projects that start late will be late to complete • Late to market means lost profit • Rush to make up for lost time causes excess cost and temptation to cut corners • Frustrated staff
Unadventurous, low-impact projects	• Poor profitability • Lost opportunities to gain market share • Poor morale
Too many projects	• Resources stretched so that some or all projects run late • Lack of management attention • Bottlenecks
Poor projects not killed early	• Unnecessary waste of money and time • Lack of resources for good projects

Mini Case 6.1

The World Bank – the Vision for Selecting Programmes[2]

Most people expect innovation to be particularly difficult in large, bureaucratic organizations. The World Bank, with its headquarters in Washington DC, might be seen as such an organization and not a hub of innovation. However, appearances can be deceptive as during the past four years the World Bank has built a reputation for being creative and innovative. How?

Much of the credit must go to the insights provided by the team at the corporate strategy unit that has radically changed the way projects are chosen for World Bank funding. The aim of the Bank is to alleviate poverty and traditionally only large, relatively conservative programmes were funded. Large amounts of money were involved so everybody wanted to make the best use of the cash available and avoid funding anything with a high risk. The decision process was normally complicated, conducted at the highest levels in the organization, and was slow.

Now the Bank has completely changed the way it selects the best proposals from the myriad it receives. The vision was to base the selection process on the way venture capitalists make funding decisions in stages and spread their risks over a range of projects rather than 'just going for the big one'. Initial funding is now available for the first stages of a programme and subsequent financing is dependent on defined results being achieved in a set timeframe. Now the World Bank is experimenting more, and is running pilot programmes to test radical ideas. The range of projects being considered and the selection process have also become highly transparent. Decisions are made by a panel of judges drawn from industry and a variety of non-profit organizations, such as Oxfam and World Vision and centres on a 'Development Marketplace'. This is done at a day-long meeting in which proposals are presented and selected in the style of an industrial show, with booths set up for each proposal, presentations and the like. Not only does this make the selection process transparent to all employees and applicants but the resulting exchange of ideas spurs everyone involved towards the production of better proposals, year on year.

Finally, managers must remember that different tools are appropriate at different stages in the life of an innovation project. In the early, investigative stages judgements may be mostly intuitive, and only later, as the facts clarify, will full financial analysis be helpful (see Figure 6.13).

Elements of a Good Portfolio

The overall purpose of portfolio management is to ensure that the organization's collection of innovation projects delivers the best value over time. The key issues that must be considered are[3]

Valuation Criteria

- Each individual project should represent good value to the organization.

- The collection of projects must make efficient use of the resources available. Where projects compete for scarce resources it must be clear how the allocation between them is to be made.

Portfolio Balance Criteria

- High-risk projects may have to be balanced by low-risk ones to ensure that the overall exposure to risk is acceptable. The organization may also want to maintain a balance of projects over time and possibly across the areas of the business.
- The innovation portfolio must fit and respond to the company's strategic needs. Perfectly good projects may have to be delayed or aborted in favour of others in more strategically important parts of the business.

Management Criteria

- The management process should be as open as possible.
- The information on which decisions are made should be collected with care, to minimize avoidable bias.
- When ongoing projects are cancelled, the process must ensure that staff motivation is retained.

We will examine each of these requirements in more detail later in this chapter.

VALUING INDIVIDUAL PROJECTS

Types of Project

In discussing valuation methods it is convenient to distinguish three generic types of project. The simplest is a *single-stage* project that is expected to run through from start to finish without interruption, as shown in Figure 6.1a. Small or low-risk projects are generally treated in this way. The second is a *multistage* project, which is conducted in phases with a progress review after each one when a decision is made whether or not to continue. This is obviously appropriate for high-risk projects and especially those where preliminary investigations are needed to establish what can (or should) be done. Projects with high levels of technical novelty, such as drug development, would be examples. It may be possible to give figures for the probability of cancellation at each phase, as shown schematically in Figure 6.1b, and these figures can be useful in valuing the project, as we show later. These are not probabilities in the normal sense but rather estimates of the confidence that managers have that the decision will go one way or the other. The third type of project is one where the reviews after each phase may lead to alternative courses of action, rather than a simple go or stop decision so that the project plan could branch into a network of possibilities (Figure 6.1c). Such *network* projects require more sophisticated valuation methods.

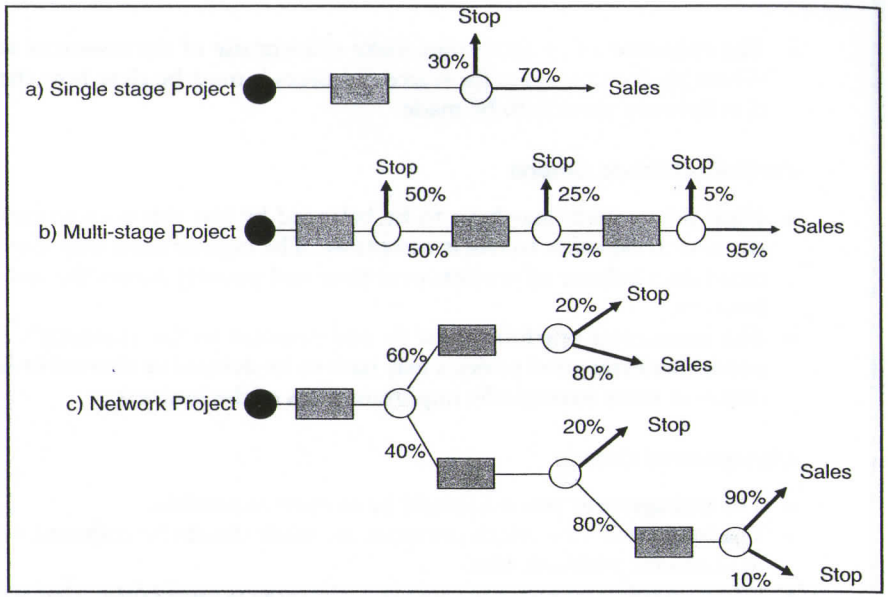

Figure 6.1 Single-stage, Multistage and Network projects

Note: The boxes are activities, the circles decision points. The percentages represent confidence estimates of which way the decision will go.

Financial Valuation Methods

The most obvious way of valuing a project is by financial analysis. Indeed this is the most common, and often the only, method used.[4] It is often necessary to supplement it by other techniques, especially in the early stages of projects when the financial data are often unreliable. But appropriate financial assessment is obviously important at any stage and should, of course, dominate the argument as the project nears fruition. The analysis can be done with varying degrees of sophistication, and somewhat different methods are appropriate for simple and for complex projects.

Single-Stage Projects

The most straightforward and the most commonly used way of determining the value (V) of a project is simply to estimate the financial benefits (B) accruing from it and subtract the costs (C) to give a net value.

$$V = B - C \qquad (1)$$

Many levels of sophistication are possible in estimating the components of this simple equation, but before we discuss them further it is worth remembering

that extra sophistication does not necessarily make for better decision-making. If the basic data are flawed or uncertain, elaborate computation will not make it any better. Indeed it may obscure the logic or, worse still, may lend a spurious authority to a fundamentally unsound deduction. Remember the adage: garbage in, garbage out.

That said, some enhancements are certainly useful. The first is to take account of the time-related value of money. Income today is worth more than income next year because money in hand today could be invested to earn one year's worth of interest. For the same reason early expenditure is more costly than later. The first modification of Equation 6.1 is therefore to take account of this effect by using *Discounted Cash Flow* (DCF). In this approach, every element of income or expenditure is discounted by a factor that takes account of when it occurs.[5] An income or cost in one year's time is multiplied by a discount factor $1/(1 + s)$, where s is the yearly cost of money: so if money costs 5 per cent a year, the discount is $1/(1.05)$, or 0.95. Income made in two years' time is multiplied by a discount factor of $1/(1.05)^2$, or 0.91, and so on.

When discount factors are included for both income and costs, the value of the project is called the *Net Present Value*, or NPV:

$$NPV = C_1 + C_2/(1 + s) + C_3/(1 + s)^2 + C_4/(1 + s)^3 + \ldots \qquad (2)$$

Here C_1, C_2, C_3, and so on are the cash flows (costs or incomes) into the project in the first, second, third time periods and so on.

The discount rate, s, should be the average cost of capital to the organization and so should include the cost of equity and of debt in the proportions found in the balance sheet.[6] Some financial managers choose a higher discount rate on the income stream as a way of taking account of a high level of risk in the project. This practice is subject to three criticisms: First, the particular figure used tends to be a 'gut feel' that can seldom be justified.[7,8] Second, it makes the assumption that uncertainty is always a negative factor, which is wrong. Uncertainty means that a project faces a range of possible outcomes, not just a single one; and this range may well include results that are better than hoped as well as worse. Third, risk is not merely an aspect of value. It is an entirely different thing, requiring specific management. Burying risk in a financial discount hides it from scrutiny and so undermines the management process.

Net present value is very widely used[9] and is worth the comparatively small amount of effort involved in the calculation, especially if the timescales of the project are long or money costs are high.

Sensitivity Analysis

The next enhancement is to estimate how robust the value of the project is. The simplest approach is to re-run the financial calculations several times with different assumptions about the major component parts. This basic and valuable step is surprisingly often omitted, even in these days of easy spreadsheet analysis. Yet the information may be critical in deciding whether to go ahead with a project

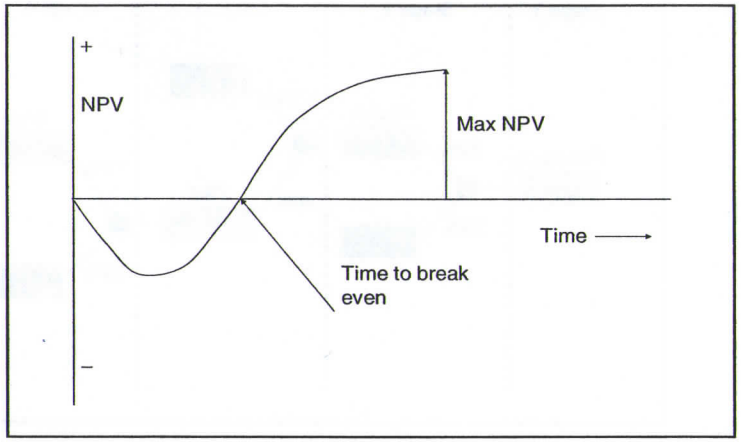

Figure 6.2 Development of the NPV of a typical project with time

if it turns out to be very sensitive to some factor that cannot be relied on. It is also very useful as the project progresses because it highlights which elements the project manager must control to ensure financial success. We will discuss this further in Chapter 7 on implementation.

Another approach to robustness is to calculate how quickly the project delivers its results. A convenient measure for this is the 'payback time', or *Time to Break Even* (TBE). The financial returns from most projects will follow a curve like that shown in Figure 6.2, starting with a period of loss when expenditure is made but income has not yet begun, moving to the 'break-even point' when the income balances the expenditure; and then on to overall profit. Other things being equal, a project with a short TBE is more secure than one that takes longer, simply because there is less time for unexpected things to happen. A more subtle approach is to calculate the *Internal Rate of Return* or IRR, which is the value of the discount factor, s, in Equation 6.2 that would reduce the NPV of the project to zero.[10] Clearly, the higher the IRR is, the more financially robust the project: an IRR of 25 per cent would mean that the interest rate would have to be greater than 25 per cent before it would be a better option to keep money in the bank than to invest it in the project. Companies often reject projects that do not meet a threshold value for TBE or IRR.[11]

Single Projects with a Risk of Cancellation

Innovative projects often face the possibility of cancellation before it reaches the end. How does one include this in the valuation? Suppose our confidence in a successful outcome is a percentage, p. There are two possible outcomes: a loss equal to the costs ($-C$) if the project is stopped; and a profit equal to the difference of income and cost ($I-C$) if not. The classical approach is to add the two

possible outcomes multiplied by their probabilities. This gives the mean or, in statistical terms the expected outcome or *Expectation*:

$$\text{Expectation} = p(I - C) + (1 - p)(-C) = I.p - C \qquad (3)$$

The result, as one might expect, is simply to reduce the income by the factor p. Notice that the effect on profit can be quite severe: a healthy 50 per cent profit margin is reduced to zero if p is 50 per cent.

But what actually is this Expectation? It is merely the average outcome to be expected from running a large number of such projects. (Just how large a number is discussed later). For an individual project however, the result will be *either* a profit of $I-C$ *or* a loss of $-C$. It will never actually be $Ip-C$; so for a single project the mean value is literally meaningless. One is reminded of the British trade union leader in the 1960s who said, 'Don't talk to me about 8 per cent unemployment. If it's you, it's 100 per cent'. He might have added '... or 0'. Certainly, faced with 8 per cent unemployment few people ask themselves how they can manage on 92 per cent of their salary. The average figure has meaning for governments but not for individuals.

Risky or uncertain projects fundamentally face a range of possible outcomes. It is a mistake (though a very common one) to seek to accommodate the risk in the valuation just by altering the estimate to another single figure estimate. We show below, however, that it is perfectly possible to compare projects and to construct an optimal portfolio without resorting to this fiction.

Estimating Probabilities in Projects

The objective assessment and management of risk is a relatively recent development in the history of human thought, let alone of business management.[12] For example, the modern concept of probability was not formulated until the mid-seventeenth century by Pascal and Fermat, who built on the earlier work of Galileo, Huyghens and others.[13,14] The fact that such illustrious names were involved should remind us that this is not an easy topic to think clearly about. Even today we are easily misled, as the number of people who believe in winning systems and 'runs of luck' at roulette makes clear.

What do we really mean when we say 'I give this project a 30 per cent chance of success'? Thirty per cent of what? And what use is the number? Let us start with the question of how to estimate the probability of an event.

In most games of chance the probability of an event can be worked out just from the logic of the situation: the chance of drawing a king from a well-shuffled pack of cards has to be 4/52 because there are four kings in a total of 52 cards. In the business world, of course, such logical simplicity is rare. Thought alone will not tell us the probability that the dimensions of a part made in a factory will fall in a particular range, or the proportion of a population who need shoes of a particular size. These must be measured. Yet it is impossible to examine every person's foot or every part made in a factory; instead one must look at a finite number of cases and deduce the underlying proportions of sizes from them.

Sampling Theory is the study of how the characteristics of a population can be calculated from measurements of a restricted sample of cases. Three considerations are important here:

- The samples must be representative of the population. There is no point in looking at a sample of Japanese people and hoping to deduce the foot sizes of Norwegians.
- The situation must be stable. If new machinery is introduced into a factory it is likely to change the process and new samples must be taken.
- The accuracy of the estimate depends on the number of samples taken. Roughly (because the details depend on the statistics of the underlying process), the uncertainty in the estimate improves only with the square root of the number of samples.[15] This means that accurate estimation requires a surprisingly large number of samples: about 100 are needed to give 10 per cent accuracy, and opinion pollsters have to interview over 1000 people to get an accuracy of a few per cent.

In estimating the probability that a particular project will be successful, one relies on comparisons with similar ones in the past. But most people are familiar with very few projects, and fewer still that are genuinely comparable to the one in hand. So these are not probability estimates at all but expressions of personal confidence based on a combination of experience and judgement. There is nothing wrong with this: it's all we have. But managers of innovation projects must recognize that these confidence assessments are very, very approximate. They can be improved by pooling the views of several people, as we discuss at the end of this chapter, but they remain expressions of confidence, not calculations of probability in the strict sense.

Multistage and Network Projects

In a multistage project, managers can take action to deal with problems as they arise, if necessary abandoning the project if its prospects become unattractive. They can also recognize good fortune and capitalize on it. Management action during the course of a project can radically improve its value and this must be taken into account in the calculations. Failing to include this 'undervalues everything'.[16] The following simplified calculation shows how important management intervention can be.

Decision Tree Analysis

Consider a project, which we will call Project Alpha, which proceeds in four stages with decision points between. Each stage has a different cost and at the start of the project, managers estimate their confidence of each being a success, in the sense that progress will be good enough for the project to continue. These are shown in the form of a *Decision Tree*, in Figure 6.3. If the project comes to fruition the expected income, appropriately discounted, is €75m.

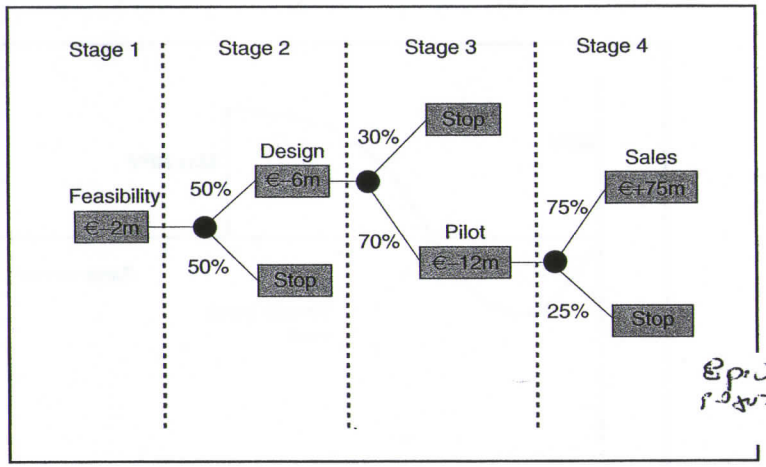

Figure 6.3 Decision tree for project Alpha

Note: The boxes show activities and their (discounted) cash flow.

The total discounted cost of the project is €20m and the overall confidence in success is 0.5 × 0.7 × 0.75 or about 26 per cent. If the project goes ahead with no intervention the Expected revenue is 26 per cent of €75m, or €19.5m. With costs of €20m, the NPV is projected to be a loss of €0.5m, so the project looks thoroughly unattractive financially.

The picture changes dramatically if we take into account the option for management to stop the project after each stage if the prospects look poor. The cost of the first stage must be included in full but there is only a 50 per cent chance that the cost of the second will actually be incurred. The third-stage cost will occur only if both the first and second phases are successful, confidence in which is 35 per cent (0.5 × 0.7). The correct calculation for the likely costs is therefore

$$€(2 + 0.5 \times 6 + (0.5 \times 0.7) \times 12)\text{m} = €9.2\text{m} \qquad (4)$$

Thus the project as a whole really has a projected NPV of €(19.5 – 9.2)m = €10.3m. This straightforward calculation emphasizes how misleading oversimplistic financial projections can be. Good management decisions add value (arguably €10.8m in the above example!). Neglecting the possibilities for choice and action during a project can lead to serious undervaluation and the likely rejection of potentially excellent opportunities.[17]

The estimated value for a multistage project derived in this way is known[18] as the *Expected Commercial Value* (ECV) and the process of analysis itself is called[19] *Decision Tree Analysis* (DTA). Clearly, it is more realistic than a simple DCF calculation for such projects, though one must always remember that the figures used are estimates, not facts.

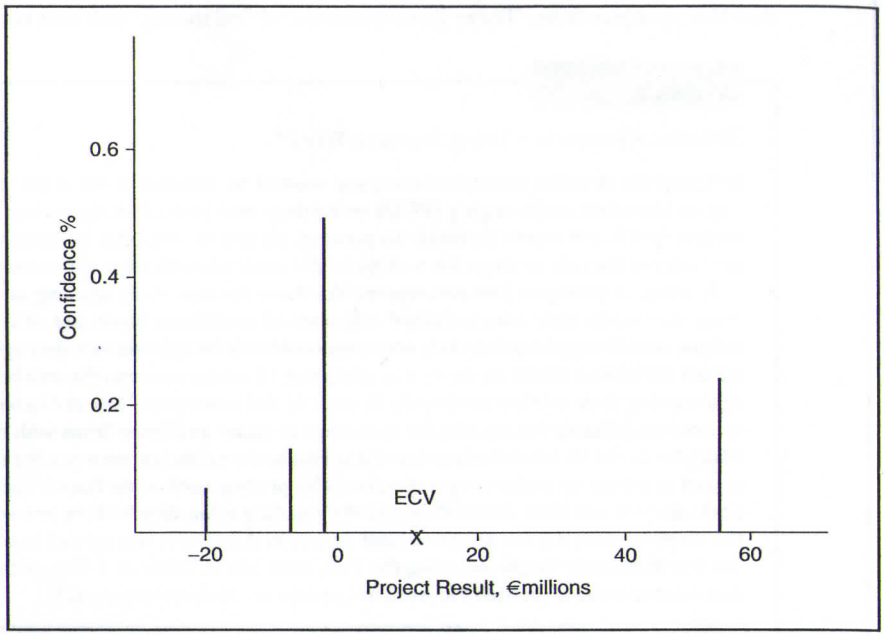

Figure 6.4 The actual possible outcomes of project Alpha

The ECV calculation yields a single figure for the value of the project, taking into account the confidence levels ascribed to the outcomes at the various stages. It is very convenient to have a single value but of course it actually represents the average outcome of a large number of such projects. If one undertook project Alpha alone it would actually have just one of four outcomes: a profit of €55m if it went to completion; or a loss of €2m, €8m or €20m if it stopped at an intermediate stage. This is illustrated in Figure 6.4. The ECV is not itself a possible outcome at all.

Monte Carlo Simulation

The range of possibilities for a project can be explored more completely using a *Monte Carlo* simulation.[20] This used to be considered a rather esoteric technique but it can now be done very easily using a spreadsheet and a simple application package.[21] The idea is to run a large number of calculations using a random number generator to represent the confidence levels in the decision tree. For example, the confidence in success of the first phase of project Alpha is 50 per cent, so the simulation first generates a random number between 0 and 100 and if this is less than 50, the phase is deemed to have failed so the simulation records a project loss of €2m and stops. Otherwise it stores the €2m cost and generates another random number to decide whether the next phase is successful. If this number is less than 30, the second phase has failed so a project loss of

€8m is recorded. Otherwise the accumulated cost would increase by €6m and the simulation would move to the next phase, and so on until completion. The simulation is then repeated. Each run will generally have a different outcome, but repeating the process a very large number of times and accumulating the results generates a full view of all the possible outcomes and how relatively often they occur.

A simple calculation such as we have just done does not strictly require the Monte Carlo treatment. But it is very useful if we wish to make the model more realistic, for example, by replacing the single values for the costs of each phase by a range of possibilities. For example, instead of putting €6m for the cost of phase two of Project Alpha the model would allow, more realistically, a distribution of cost between perhaps €4m and €7m. Figure 6.5 shows the result of a Monte Carlo simulation of a project similar to Project Alpha, where ranges of costs and of income have been allowed in place of the single-point estimates.

The Monte Carlo simulation is a helpful and surprisingly easy technique to use. It has the healthy effect of showing the full range of possibilities that management may actually face on the particular project. Of these outcomes the 'average' may itself actually be very unlikely – as it is, for example, in the project shown in Figure 6.5.

Comparing the Values of Risky Projects

The additional information provided by this more complete analysis is helpful in managing the project but the complexity of diagrams such as Figure 6.5 does seem daunting when it comes to making priority decisions between projects.

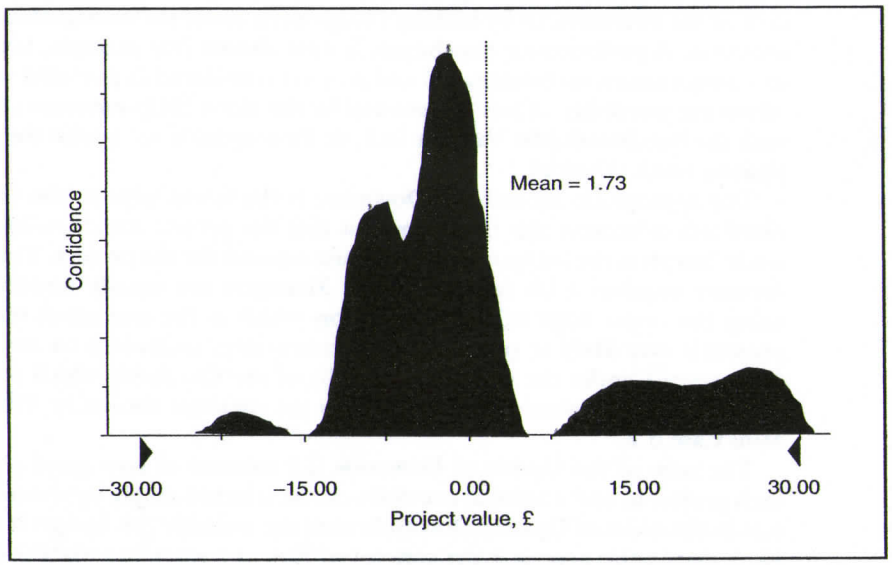

Figure 6.5 Result of Monte Carlo simulation for a project similar to project Alpha

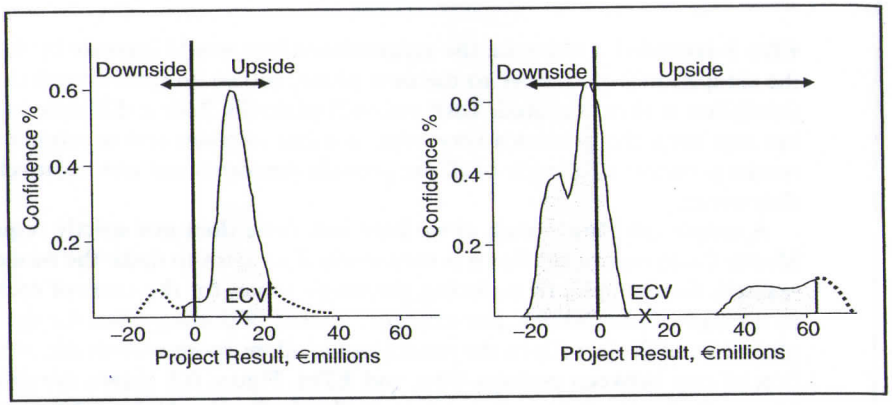

Figure 6.6 Two value distributions truncated to remove extremes, showing their different Upside and Downside measures in relation to a benchmark

However, comparisons can be made quite simply by treating each project as a wager in which the possible loss is balanced against the possible gain.[22] The most attractive project is the one with the best balance. One must first recognize that the detail of the probability diagrams has no predictive value for individual projects for the reasons already explored, so the analysis should aim merely to establish upper and lower limits of the value – the best and worst outcomes that are reasonably likely to happen. This will usually involve rejecting the tails of the distribution as shown in the two different cases illustrated in Figure 6.6. This may be done by rejecting the upper and lower tails representing, say, 5 per cent of the outcomes; or by making a judgement about the manageability of the extremes. A performance benchmark is then chosen (for example, break-even or a target return on investment) and projects considered as potential wagers in which the possibility of loss represented by the worst likely outcome compared with the benchmark (the Value at Risk, or Downside) is set against the possible positive result (Upside).

The appropriate measure of Downside is the lower edge of the truncated distribution because this is the amount that the project stands to lose in the worst case; it is the budget managers must commit for the project. The Upside measure requires a bit more thought. Managers are usually uncomfortable using the upper edge of the distribution which is the maximum return the project is ever likely to make. A more conservative measure is to use the area (or integral) under the curve to the right of the threshold, which represents the *probability-weighted* Upside. This was the measure chosen by Embraer in Mini Case 6.2.

The ratio of the Upside to Downside is a measure of how good a prospect each project is, and a rational portfolio can be selected simply by choosing projects in the order of Upside/Downside until the available risk budget is used up. Note that in this approach the concept of Risk as a separate variable disappears

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entirely. Risk is seen merely as a way of thinking about the range of outcomes that each project faces. There is no question of 'balancing' risk and return.

Mini Case 6.2

Embraer Aerospace – Using Decision Trees[23]

Embraer, the Brazilian aerospace company wanted to determine the most effective way to introduce radio tagging (RFID) technology into part of its operations. It was unclear whether it would be better to proceed via one or two-pilot implementations to minimize the risk, or to go for a single implementation with no preliminaries.

A group of managers first constructed the three decision trees working as a team. They then made their own individual estimates of confidence levels and of cost and income data. Recognizing that their estimates could only be approximate they agreed to set the confidence values on the tree by allocating 12 tokens between the tree branches representing their relative confidence in each of the outcomes. They estimated costs or incomes (suitably discounted) for each stage as upper and lower limits with either a triangular or flat distribution between them. Finally, the estimates were pooled and discussed as a team to come to agreed values. This process took a few hours. The Monte Carlo analysis was then done offline and the resulting value distributions presented to the team the next day for discussion and review. In this case it was agreed to truncate the distributions by simply removing the 5 per cent tails at either end. One of the decision trees and the associated Monte Carlo results are shown in Figure 6.7.

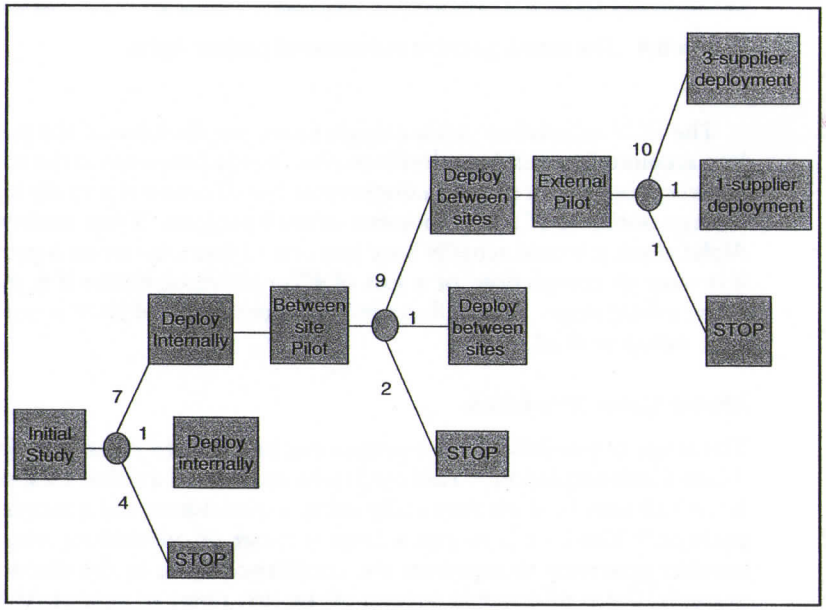

Figure 6.7 Decision tree and Monte Carlo simulation for RFID project for Embraer

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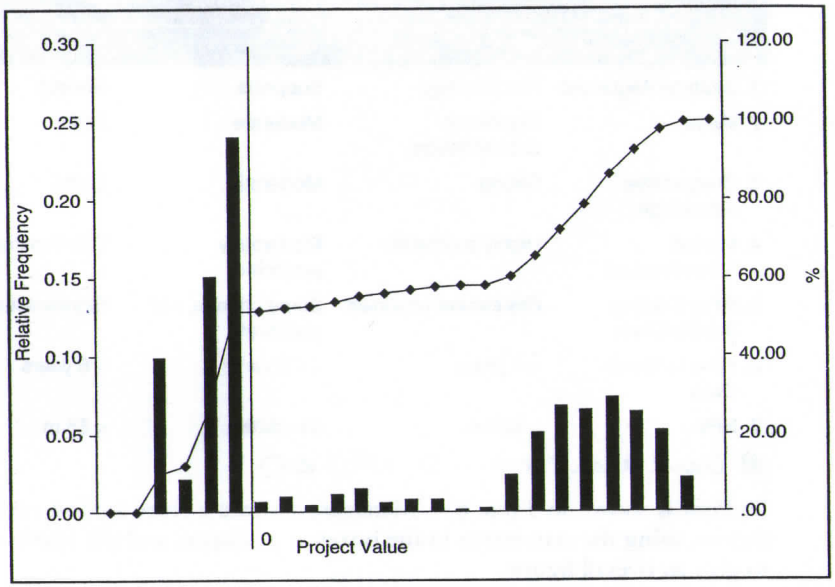

Figure 6.7 Continued

Table 6.3 Comparison of Three Strategies for RFID Implementation

	Highest value (HLV) $	Expected Upside/ Downside	Mean $	Expected Upside/ LLV
No pilot	475	3.1	135	1.0
1 pilot	765	3.2	160	1.25
2 pilots	697	5.3	190	1.0

Best "expectation"

Most secure "bet"

Source: Case adapted from Mitchell, Hunt and Probert, 2010.

Table 6.3 compares the main parameters of the confidence distributions for the tree implementations. This shows that although the mean, or expectation value, is highest for the two-pilot implementation, the one-pilot case gives the best ratio of Upside to LLV, which, as argued above, is a more secure basis for choice. This is the implementation that the company chose to follow.

Valuing Large and Small Portfolios of Projects

We have already emphasized that the ECV or mean outcome is a misleading concept when applied to an individual project. Nevertheless, it can be used for sufficiently large portfolio. This is because the uncertainties in the individual projects tend to cancel out, and so as more projects are added the value of the whole portfolio becomes relatively closer to the sum of the means of the individual projects. Unfortunately, the uncertainty reduces rather slowly as the size of the portfolio increases. Roughly (because the details depend on the statistics) it takes 10 projects to reduce the relative spread to 1/3 of what it was for one project, and 100 to reduce it to 1/10 – and that is assuming there is no correlation between the factors causing success or failure in the projects, a rather bold assumption if they are happening in the same organization. Any such correlation slows down the reduction of the spread.

Anyone who uses the mean as the measure of the value of a risky project is implicitly assuming that it forms part of a very large portfolio. This may be right, but very often it is not.

Real Options

Many authors[24] have noted that projects in the physical world have much in common with financial instruments called *Options*. An option on a stock is a contract that allows, but does not compel, the holder to buy that stock at a fixed price at some point in the future. If the price of the stock goes up, the holder of an option can make money by exercising the option and then selling the stock at the (higher) prevailing price. However, if the stock goes down, the option holder does not have to make a purchase and loses only the cost of purchasing the option itself, which is usually much less than the value of the stock. Many innovation projects have the same logic in that they give management an option, but not the obligation, to take an innovation forward after each stage. This analogy suggests that the extensive theory developed for valuing financial options might be applied to valuing the flexibility that managers have in managing projects. This is known as the *Real Options* approach to valuation.[25] Its application to innovation projects, and especially to new product introduction, is an area of active research at the moment.[26]

The theory of option valuation for financial stocks was worked out fully in the 1970s by Fischer Black, Myron Scholls and Robert Merton (BSM). The full treatment involves an elegant partial differential equation, the Black-Scholls equation, which allows analysis of a large range of varied cases.[27] The analysis has been extremely influential in the financial community but attempts to apply it to innovation projects have not been particularly convincing and we consider that the idea is flawed because the financial and project domains are seldom closely comparable.[28] The first discrepancy is that in the BSM treatment the value of the stock follows a 'random walk' path, with its possible range spreading upwards and downwards as time goes on. This means that the possibility of gain from holding an option increases over

time, so the value of a long-dated option is greater than a short-dated one. This is a good model for the stock market where securities can be traded at any time but innovation projects generally have no realizable value until they are complete. Moreover, the value of the options that they provide is more likely to decline with time because of competitive pressures, expiry of patents or market lifecycle. If it were not so managers would be observed diligently slowing down their innovation projects! The second discrepancy is that the BSM analysis relies on being able to identify a *hedge position*. In essence a hedge is a mirror image of the stock: an asset whose value tracks it in reverse, going down if the stock goes up, and up if it goes down.[29] In the world of innovation projects, however, much of the risk will be within the project itself (so-called *specific*, or *private*, risk) and cannot usually be hedged. How could one arrange to profit from an idea that simply proved to be unworkable? Real options may be useful in evaluating 'real' projects where the risks are mostly in market conditions but not for the majority of innovation projects where most of the risks are internal.

Non-financial Methods

In an ideal world financial calculations would be all you need in selecting projects in a portfolio. Unfortunately, the financial information available in the early stages of a project may well be incomplete or unreliable – or more likely, both. There are two reasons for this: the first is that the completion date may be some way in the future so there may be genuine uncertainty about what can be achieved and what the customer's reaction will be. The second is that developing a detailed business plan with reliable financial information requires a lot of effort that companies may feel is not justified when the project is still in the concept stage. So even if realistic financial projections could be made, the truth is that they seldom are. This fact is well attested by research: in a wide-ranging study, Robert Cooper and co-workers[30] found that of all the possible ways of selecting projects, practicing managers had the least faith in purely financial projections.

The limitations of financial projections have led companies to look for more broadly based approaches to portfolio management in which financial data may be included but as only one of several factors. The approach is analogous to the *Balanced Scorecard* approach to measuring company performance.[31] The argument is that where financial figures are considered unreliable one can improve the project selection process by including other criteria that are known to be well-correlated with the success in new products.[32,33] The simplest set of such generic factors for a new product might include market size and growth rate; level of competition; how well the project fits with company strategy and so on. But companies will often use factors that are more industry-specific.

The criteria may simply be used as a checklist to guide the review process and ensure that all relevant factors are being considered. Alternatively managers may allocate a score against each factor and so arrive at an overall score for each project to give a clearer sense of priorities. An example of such a process used by

Table 6.4 Project Scoring System Used by Dupont[34]

	Score		
	15	10	5
1. Strategy Alignment	Fits Strategy	Supports	Neutral
2. Value	Significant differentiation	Moderate	Slight
3. Competitive Advantage	Strong	Moderate	Slight
4. Market Attractiveness	Highly profitable	Moderately profitable	Low Profitability
5. Fit to Existing Supply Chain	Fits current channels	Some change, not significant	Significant change
6. Time to Break Even	< 4 years	4 – 6 years	> 6 years
7. NPV	> $20 m	$4 - $20m	< $5 m

DuPont is shown in Table 6.4. Managers allocate a score against each of seven factors, using the statements in the boxes as guidance, and the results are added to give an overall figure.

Designing and Using a Scoring System

Checklists and scoring systems usually have to be customized for the job in hand. For example, the system used by Domino Lasers a company with a restricted product range and a turnover of $30 million at the time (see Table 6.5) is quite different from that used by Dupont, a diverse company with a turnover closer to $30 billion. Indeed, different criteria may apply for different types of projects. Managers at a large engineering company once told us they had rejected scoring methods because they 'rejected all the innovative projects'. The problem turned out to be that they were selecting research proposals using a checklist designed for small product improvements. Its first three items, Technical Risk, Commercial Risk and Financial Risk, though quite appropriate for minor enhancements, were enough to kill off any really novel idea.

Designing a checklist or scoring system is a useful learning experience for the management team and there is plenty of help in the literature[35] so the time spent is not wasted. The following issues are the most important:

- Avoid too many factors. There must be enough separate points to give structure to the debate and to ensure that nothing important is overlooked, but too many can inhibit good discussion. Six factors are probably about right, ten the maximum.
- Avoid factors that express the same issue in different ways, such as 'sales' and 'market share'. This leads to overemphasis of one factor.

- Ideally, the factors chosen should be of roughly equal importance, if only because the team will probably spend roughly equal times on scoring each of them. Of course it is possible to allocate a weighting to each factor and then multiply the scores by these weightings. But beware of spending more time discussing the weightings than the projects!
- The scales used for the factors should as far as possible represent equivalent value to the organization. For example, in Table 6.5 the scales for Increased Sales and Cost Reduction were chosen so that a particular score on either would yield approximately the same profit level, taking into account the financial structure of the business.
- Demand facts and numbers rather than 'gut-feel' responses wherever possible.

An important part of constructing a project scoring system is to give adequate guidance on how to interpret the scales. It is arguable that DuPont does not go far enough in this respect; for example, people with the same opinion of the competitive advantage of a project may have different views about whether this should be given the rating 'strong', 'moderate' or 'slight'. This unnecessary ambiguity can be reduced by using a more complete set of *anchoring statements* to help ensure that all participants use the scales in a comparable way. (An alternative is for certain people to be responsible for scoring one parameter for all projects – see the main case for this chapter: Britannia Building Society. This at least ensures consistency.) A set of anchoring statements, used by Domino Lasers, is shown in Table 6.5.

There are different opinions about whether scoring should be done individually or as a group and whether a group should aim to reach a consensus on each factor. The advantages of sharing information in an open way are obvious but it has often been noted that the discussions and conclusions can be driven to a false consensus driven by one dominant or senior member.[36] We discuss these issues in more depth in the final section of this chapter.

The value of scoring systems often lies as much in the discipline of collecting and discussing information on all aspects of the project as in the final scoring. Helpful as they are, these are rough-and-ready methods designed to aid decision-making in highly uncertain situations. If one project should score a few points more than another, recognize that the precision of the tool is not enough to differentiate them. Find another consideration – the quality of the project manager or the morale of the team perhaps – to separate them.

Scoring systems are very widely used in project selection but our experience is that people often have a vague feeling of dissatisfaction with them. Probably this is simply because scoring is used most often in the early stages of projects when information is clearly patchy and nobody feels really comfortable in making decisions. However, it is the best – indeed virtually the only – technique that is suitable for such situations.

Table 6.5 Project Scoring Matrix Used by Domino Lasers with Anchoring Statements (see also Mini Case 6.3)

	Rating	0	4	7	10	Total
'HARD'	Key Items					
	Increased Sales (or lost sales saved) in first 3 years after launch	None	$2 million (e.g., 100 machines at 20K)	$4 million (e.g., 200 machines at 20K)	$6 million (e.g., 300 machines at 20K)	
	Cost reduction savings over 3 years	None	$0.5 million	$1 million	$1.5 million	
	Price premium/gross margin in target market	Worse than in our main business	Margins similar to our main business. Little or no price premium	Improved margin. Price premium equivalent to $1m over 3 years	Significantly better margin. Price premium equivalent to $1.5m over 3 years	
	Channel cost or efficiency benefits	More difficult to sell or service than existing products. Significant training needed	Selling and servicing much the same as existing products	Easier to sell or service than existing products. Efficiencies worth $1m over 3 years	Significant benefits to the channels. Efficiencies worth $1.5m over 3 years	
'SOFT'	Customer impact	Offers no unique customer benefits or features	Some unique benefits. Enhances corporate image	Clear unique benefits. Something to talk about. A 'door opener'	Eye-catching benefits. A talking point at shows, gives an entry to competitor laser accounts	
	Technology offers a platform for growth	Dead end/ one of a kind	Can be used in other products or for business expansion	Potential for use throughout the business or for business expansion	Opens up entirely new markets	
	Comments					Total %

Mini Case 6.3

Domino Lasers – Portfolio Scoring[37]

Simon Bradley, the Managing Director of Domino lasers a manufacturer of laser systems based in the USA and Germany, became concerned that the company was concentrating too much on small, low-impact projects, possibly to the exclusion of larger but riskier enterprises. The company had between 10 and 15 projects in hand, some quite mature but others in the early formative stages. Bradley wanted to include the management of the newly acquired German subsidiary in the review of the project portfolio to ensure there would be support from all parts of the company for any changes that had to be made. But it would not be easy, as it was clear that managers in the two parts of the company had different tolerances of risk. The two teams also tended to emphasize different aspects of the market, the Americans being more used to seeking high-volume opportunities while the Germans tended to pursue applications with lower volume but higher margins. Doing a portfolio analysis together could help to align the views of the two management teams but there would have to be a clear structure to guide the discussion.

Bradley spent some time in preparing a structured risk-reward analysis. It had to be useable for early-stage projects, where detailed financial information was not available, as well as for more mature ones. Carefully anchored scales were clearly needed to help align the approaches of the two teams. The scales used are shown in Tables 6.5 and 6.6.

A trial run for the scoring system quickly revealed a problem. While all the participants were familiar with some of the projects, almost nobody really understood them all. The review could not go ahead without more shared information. Accordingly, three of the participants undertook to collect data on all the projects and circulate it for comment and review so that at the next meeting everyone would start from an agreed set of facts.

The teams met by video link to discuss the projects and assign scores for risk and reward to each one. Richard Blackburn, manager of the US factory commented:

> We started out trying to reach a consensus on each factor but we quickly decided that if there really was a range of opinion about something then we ought not to lose sight of that. So we discussed the facts of each project and then scored them individually. Then we discussed the scores. Sometimes people changed their minds when they understood where the others were coming from, but not always. At the end we recorded the range of each score as well as the mean. People felt much more comfortable not trying to force a consensus.

Bradley comments: 'The most useful thing about the scoring system was that it forced us to think about all the aspects of the projects – not just the cost and technical feasibility, which had tended to dominate our thoughts before. For example, we had a couple of research projects where the biggest risks were actually to do with the market acceptance. So we decided to put effort into the market research first and hold off on the technical work for the moment'.

Choosing a Valuation Method

Every evaluation method has its strengths and weaknesses, and the choice of which to use depends on the level of uncertainty and the amount of choice open to managers as the project progresses. An NPV calculation is appropriate for a

single-phase, relatively low-risk project. However, if there are many decision points, ECV or a Monte Carlo simulation are more useful. Greater uncertainty demands an Internal Rate of Return calculation at least, or a switch from financial methods to a scoring system. It is often appropriate to use several methods to provide extra certainty, as Agilent found (Mini Case 6.4).

The choices are illustrated in Figure 6.8.

Mini Case 6.4

Agilent – Riding the Market Waves[38]

Agilent Technologies provides testing technology for communications, life sciences, chemical analysis and semiconductors. Within the semiconductor test business (which became independent as Verigy in 2006) the Systems on the Chip Business Unit (SOC BU) has four manufacturing and R&D sites employing over 650 employees who develop and manufacture a range of highly sophisticated 'chip testing solutions'. These products cost between $600K and $4M. Agilent's customers include 'testhouses' (high-volume integrated circuit testers) and many of the major electronics manufacturers worldwide.

Financial management is given much emphasis at Agilent and the financial controller of the SOC BU, Werner Widmann has deliberately spread his team across the four sites. This ensures the close cooperation necessary with all aspects of the business, from hardware and software R&D, to marketing, to manufacturing and supply chain management.

Key success factors in the chip tester business are time-to-market; meeting the customers' demanding technical specifications; and achieving fast, low-cost chip testing. The business is highly volatile – within a year the quarterly sales figures can fluctuate by as much as 150 per cent. With such uncertainty, it is difficult to maintain R&D spending during downturns in the market; so part of Widmann's responsibility is to ensure that the SOC BU makes significant return on investments during the market upturns and does not suffer from cash flow problems during the downturns.

To deal with the challenges Widmann's team has adopted a much wider role than many financial controllers. 'For example, my team led a Portfolio Management Taskforce to develop tools and processes to support top management in the SOC BU Business Board', he says. Gauging the technical risks of a project, and forecasting product sales are notoriously difficult so the team developed a set of tools to be used in parallel. These are based on portfolio assessment questions, market uncertainty analysis and project scoring matrices. Communications throughout the worldwide management team have been significantly improved through the adoption of this standard set of portfolio management tools. And, to promote learning, managers' previous estimations of sales and risks are compared with actual figures and fed back to them. 'The new SOC BU Portfolio Framework has greatly helped in the way it presents the data and makes the trade-offs visible. The Management Team now has the information it requires to make fact-based decisions on which projects to back and which to kill, or postpone. We are now starting to get much better at understanding market attractiveness and risk' says Widmann.

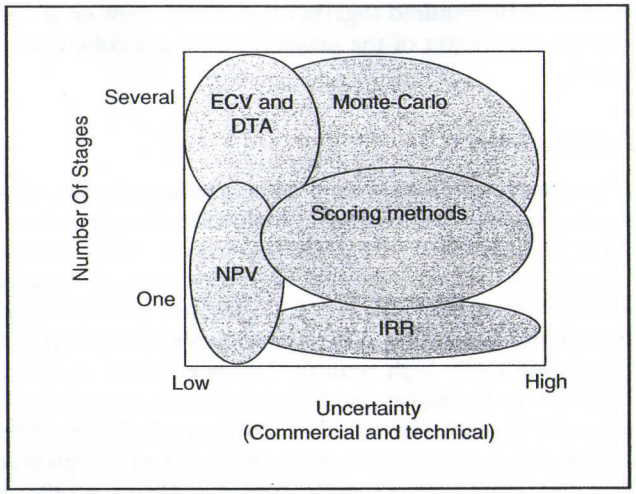

Figure 6.8 Appropriate valuation methods for different types of project

CHOOSING AND MANAGING A PORTFOLIO

Ranking Projects for Selection

Assigning a potential value to each project, by financial calculation or scoring, is the first step in managing a portfolio. The projects can now be ranked in terms of Upside/Downside ratio or by return on investment. Money is the most usual criterion of course, but other things may be important. Progress may be limited by the availability of specialist staff such as good project managers; or it may simply be a departmental budget that cannot easily be changed. Portfolio selection then amounts to getting the best return from this bottleneck resource. Return on investment may be replaced by some other ratio such as 'Return on R&D spend' or 'Return on marketing spend'. If a scoring system has been used, rather than financial assessment, the expenditure may already be factored into the score, giving an overall figure of merit directly.

Actually, of course, each project in the portfolio will use a variety of resources, human and material. Mathematical optimization techniques are available to calculate how to select the group of projects that will produce the best financial return subject to the constraints on several different resources. However, such techniques seem rather seldom used in practice,[39] probably because the mathematics hides the process. Managers cannot readily review or justify the results, nor can they adjust or amend them to take account of other factors. And how do you explain to a team that their project has been terminated because an optimization programme said so? Better to use simpler methods that help to clarify the logic, without removing the scope for management judgement and interpretation.

Managers will often start the project selection process by discarding all proposals that do not offer a certain return on investment, or that fail to achieve

a required score, or have too long a payback period. The remainder may now be ranked in terms of financial returns or score and, if no other considerations were involved, one would simply select from the top as many projects as funds or facilities allow. However, in practice the overall balance and strategic fit of the portfolio must also be considered and we consider these techniques in the next section.

Balance

The first aim of portfolio management is to assemble a collection of projects that all represent potentially good value to the company and good use of its resources. We must next consider whether the portfolio represents a good balance of activities in other respects, in particular, *strategic alignment*; *time and resources*; and the *risk/reward* profile.

Strategic Alignment

The first aspect of portfolio balance to consider is strategic alignment. For example, if a company has a long-term aim to move into a new technology or to enter a new market, a proportion of its innovation investment must be in projects directed towards that end. This priority may override most others and so must be injected into the portfolio management process by some 'top-down' approach that gives special emphasis to projects that express the strategic thrust of the organization, at the expense of others.

There seem to be only three generic ways in which strategic aims can feed into portfolio management. The first is by directly earmarking money for a group of projects, perhaps identified by a roadmapping process (see Chapter 4), that constitute a plan to achieve the required strategy. The resources for these strategic projects must be 'ring-fenced'. Certain types of projects may receive priority treatment as a matter of course: safety issues or compliance with legal regulations would be examples.

The second approach is for management to declare that, as a matter of policy, a certain amount or proportion of funding will be allocated to particular types of project. This approach is known as *strategic buckets*. It may mean allocating funds to particular market sectors or product types (Figure 6.9) or to certain classes of project. The AXA insurance company,[40] which provides our main case study in Chapter 3, aimed that 10 per cent of its innovation projects should be entirely novel, 10 per cent should be based on the reuse of existing ideas in new applications, 40 per cent should be incremental improvements and 40 per cent should eliminate unnecessary activities.

The third approach is simply to include strategic priorities as factors in the project scoring system. This gently guides the selection process in a particular direction rather than imposing an overt policy.

Time and Resources

The projects in the portfolio must also be balanced with respect to completion times. A spread of delivery dates will usually be desirable because there

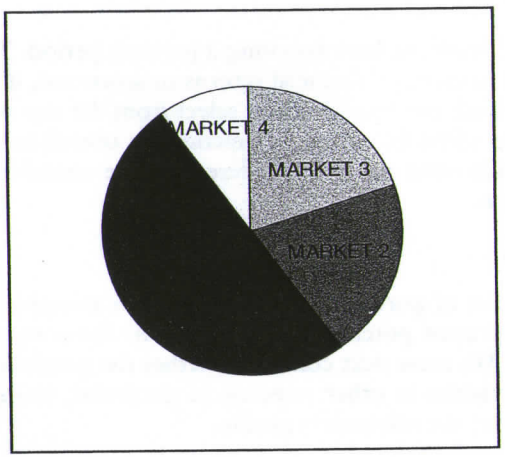

Figure 6.9 Strategic alignment of project budgets according to markets served

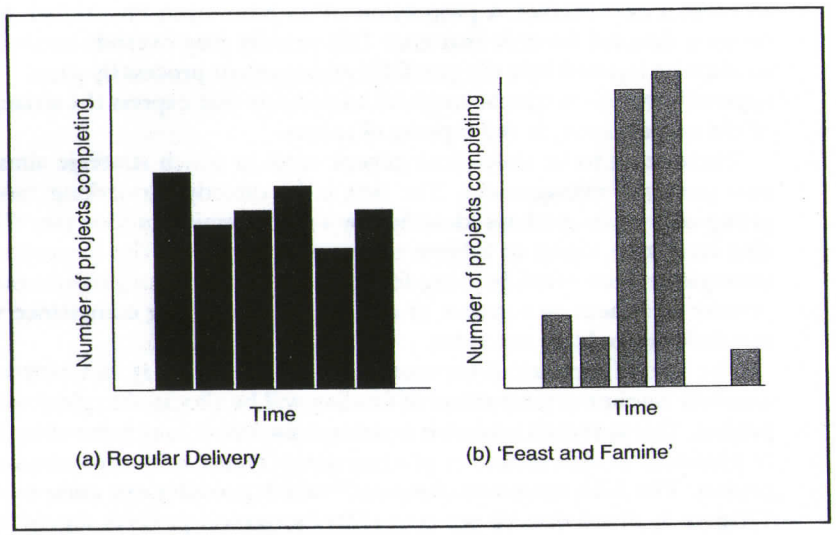

Figure 6.10 Time balance in a project Portfolio

will be a limit to how much change an organization can manage at one time. A steady flow of new products is generally more motivating for the sales force and easier to handle throughout the supply chain than a glut followed by famine (Figure 6.10). On the other hand, there may be good reasons to launch

some innovations together to maximize their impact. For example, several new products may be required together for a trade show or an exhibition. Whatever the reason, the timing of the projects in the portfolio must be considered and managed.

Risk and Reward

Another important element of portfolio balance is risk. Organizations may be willing to take on some high-risk, high-reward projects but only if they have a sufficient number of low-risk projects going on at the same time to provide security. Conversely many companies worry that they are 'risk-averse'. By this they do not mean that they take too few gambles, but that they do not undertake enough of the long-term, difficult and innovative projects that have potential for generating really high returns. The *risk-reward* or *risk-impact* diagram is a convenient way to display the balance of risks among the projects and so aid decision-making (see Figure 6.11). Projects are displayed on a grid where one dimension is a measure of the estimated value of the project – for example, its NPV or the rating from a scoring system – while the other is a measure of the uncertainty or risk of the project. The diagram gives a display of the state of the portfolio but not a diagnosis of how healthy it is. That is left to the judgement of the management team.

There are several good reasons for separating perceptions of risk from perceptions of value in this way:

- Risk and reward are different things and require different kinds of management action. The potential reward from a project is often determined mostly by external forces and so is relatively constant, while risk, particularly technical risk, can often be dramatically affected by some investigative work or experiment.
- Risk and reward often become entwined in our minds in unhelpful ways. We have already observed that managers often down-rate their estimates of the potential of projects as a way of accounting for the risks. Risk does not necessarily make a project less valuable; it may merely mean that work is needed to clarify the situation.
- When there is doubt about feasibility, it is all too easy not to ask basic, and perhaps easily answered, questions about value (and vice versa). We have heard managers argue: 'There's no point in worrying about the market when we don't know whether the thing will work'. As a result much time and money is wasted in proving the feasibility of some product that in fact had no market potential. Separating risk and reward explicitly poses questions and prompts action on both.

Figure 6.11 is a typical risk-reward diagram. It shows the balance of the portfolio between the four quadrants, which are often named as *Bread and Butter* (low risk but low rewards); *Pearls* (low risk and high rewards); *Oysters* (high risk

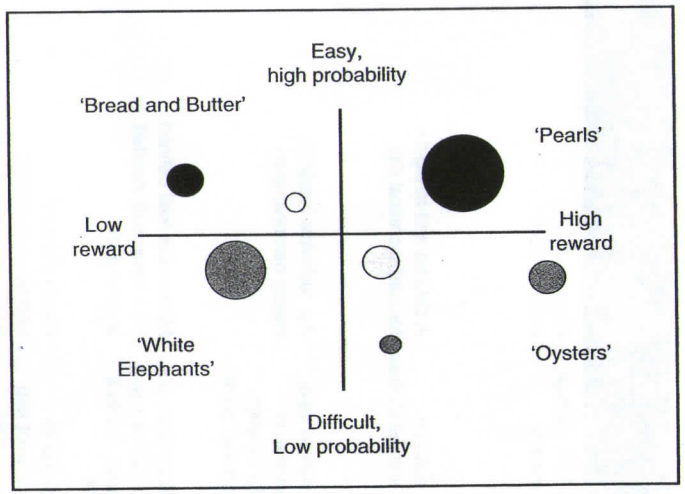

Figure 6.11 Risk-reward matrix

but potentially high reward); and *White Elephants* (high risk, low returns – and proverbially difficult to kill!). In this figure, the area of the circles represents the investment in the current phase of each project and so the diagram shows the distribution of effort over the whole portfolio. The shading can be used to show how near the projects are to launch, or for any other distinction – for example, to show which market sector or part of the business they relate to. Fruit of the Loom (Mini Case 6.5) used it to show how their innovation projects related to the critical stages of their manufacturing process.

The fact that projects may be found in any part of the risk-reward diagram emphasizes the point we made in the section on Real Options: that the world of projects is very different from the world of financial stocks. In the financial world the operation of the market ensures that low-risk stocks generate a low reward and high reward goes only with high risk. Innovation projects are generally quite different because the assets that they represent are not traded openly. No market mechanism operates against Pearls or White Elephants.

A risk-reward diagram carries a lot of useful information in a simple and accessible way but managers must use their own judgement to decide whether the portfolio best meets the needs of the organization. Such diagrams are most useful for early-stage projects. Scoring systems will usually be used to position them on the axes and the balance between risk and reward is determined intuitively. In the later stages, when enough financial information is available to draw value-confidence plots, the more formal and logical methods described above can be used.

Scoring the Risk Dimension

Risk is very difficult to estimate but a carefully designed scoring system can take some of the subjectivity out of the process. The principles are exactly the

Mini Case 6.5

Fruit of the Loom – a Portfolio of Process Innovations[41]

Fruit of the Loom is an international clothing manufacturer employing over 23,000 people and based in Bowling Green, Kentucky. The business is strongly vertically integrated, spanning the complete product process from spinning the yarn and weaving and dyeing the fabric, to creating and packaging the final garment. Consequently the company is very diverse, operating from over 50 sites around the world.

Process innovation – ranging from improvements in existing processes to the application of radically new manufacturing technology – is very important to the continuing success of the company and the target for regular significant financial investment. Management were concerned that, without some central coordination, innovation efforts might be concentrated in too few parts of the business. Moreover, the best practices being developed in some parts of the business were not necessarily being shared with all the sites that could benefit. In 1998, Dr Michael Mallon, VP Manufacturing and Sourcing, set out to understand the portfolio of process innovation projects better, aiming to get better value for money and to ensure that all parts of the business were receiving appropriate attention: 'Previously, each process innovation investment had been assessed individually purely on a financial basis. There also wasn't much interaction between the different functional areas involved. We wanted to improve this process.' Mallon looked at how product portfolios were managed and started to apply these ideas to Fruit of the Loom's process innovation – probably the first company to apply this level of sophistication to process innovation projects.

A survey across all sites showed that more than 100 process innovation projects were being conducted. A portfolio bubble diagram was prepared showing the expected return on each project in one dimension and the degree of innovation in the other

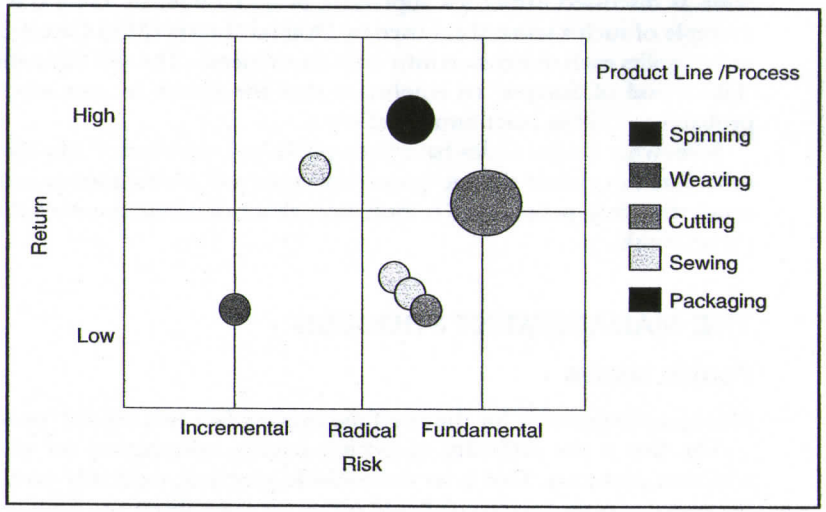

Figure 6.12 Risk-reward matrix used by Fruit of the Loom

▶▶

(Figure 6.12 – simplified to show only a few projects). Financial returns were estimated using 'Expected Manufacturing Benefit' (EMB) – a calculation based on the ideas of ECV. The size of the circles on the diagram represents the level of investment. Some projects at different sites were found to be very similar; a clear waste of precious resources. So the first task was to eliminate duplication while ensuring that the experience gained from the selected projects was made fully available across the company. Once this was done, attention moved to prioritizing the remaining projects. Colour coding was added to the bubble diagram to show the stage of the manufacturing process (spinning, sewing, weaving, packaging and cutting) involved. The resulting diagram allowed managers to see the complete balance of their innovation programme on a single sheet. 'This forced all functional areas to sit down and discuss the portfolio in detail. Not only do we consider each individual project but we monitor whether we were innovating sufficiently at each of the process stages, such as spinning and packaging.' As the diagram indicates, the more radical innovation efforts were concentrated on the clothing stages, and packaging, a promising area for cost reduction, was being neglected.

It is now several years since Fruit of the Loom introduced process innovation bubble diagrams. However, as Mallon says, 'my colleagues still find them a highly relevant tool that creates the interaction necessary to make better investment decisions. Combined with our improved approaches to assessing technical risks, EMB, and even whether the appropriate human resources are available has helped us become much more effective at managing our manufacturing technology. Senior managers have welcomed this more formal process, as they see that it has delivered significantly superior projects than was previously the case.'

same as discussed earlier for appraising project value. In Table 6.6 we give an example of such a score-sheet used by Domino Lasers (Mini Case 6.3). This risk matrix splits each dimension into only six elements. The risk dimension is called 'Likelihood of Success' to emphasize that the scores are not supposed to be probabilities in the strict numerical sense.

Somewhat similar scales have been published elsewhere.[42] Having a checklist of factors can ensure that no major aspects of risk are forgotten; and anchoring statements help people turn information about uncertainty into a shared assessment of risk.

THE MANAGEMENT PROCESS

People Issues

Managers responsible for the portfolio process face two related 'people issues'.

The first is the difficulty of getting reliable information on which to base selection decisions. This is an unavoidable problem, especially early on, simply because decisions have to be based on predictions about the future, not just on facts about the present. But it is compounded by the fact that the people who

Table 6.6 Scoring Sheet Used by Domino Lasers for Assessing Project Risk (see Mini Case 6.3)

	Rating	0	4	7	10	Total
'TECHNICAL'	Key Items					
	Size of technical (in at least 1 parameter)	New concept or order of magnitude change	Step change short of order of magnitude or significant novelty of method	Less than 50% change. No major novelty	Incremental improvement	
	Technical uncertainty	Many major technical uncertainties or very high complexity	Several significant technical uncertainties or high complexity	Technical solution defined but uncertainties remain	A defined and straightforward technical risk	
	Demonstrated feasibility	Have not yet been able to demonstrate feasibility	Limited demonstration achieved. Or outline plan for cost reduction	Almost demonstrated. Full demonstration planned. Or detailed plan for cost reduction	Full technical feasibility clearly demonstrated	
	Knowledge of market for this product	Pure guesswork	Rough estimate available but no specific study yet done	Specific study done but more work needed. (e.g. market known within a factor of 2)	Market size well defined. No further work needed (e.g. +/-20%)	
'COMMERCIAL'	Market readiness	Extensive market development required. No apparent demand	Need or benefit must be highlighted to customers	Clear relationship between product and customer need; or substitutes a competitor product	Meets a clearly expressed customer need; or substitutes one of our products	
	Channel capability	No relevant expertise or experience in our channels	Some relevant experience or expertise	Considerable relevant resources available	Leverages our existing skills and resources well	
	Comments					Total %

know most about a project are those working on it, and they have a vested interest. Project selection can degenerate into a contest of advocacy skills between passionately committed, and not necessarily objective, project leaders. The only way out of this is to make the collection of the information that is used in the selection process as open and objective as possible, and to allocate enough effort to reviewing it. Larger companies can make good use of experts from other departments. A good example is the process used by SmithKline Beecham (now Glaxo SmithKline) and described in Mini Case 6.6, in which they took pains to separate the valuation of projects from the final portfolio selection.

Since all predictions contain an element of judgement, it is clearly best not to rely on the view of a single person but to seek and combine the views of several people – provided they all have the requisite competence. The improvement that can come from numbers can be negated if a powerful or charismatic figure dominates the proceedings so if the views are pooled in an open meeting it must be carefully managed. The Delphi process[44] avoids this problem by having each participant put forward his or her opinion anonymously. The group discusses them without seeking to identify who said what. A further round ensues, and continues until consensus is reached. Originally this was done by letter or email. A modification that we have found works well is for participants to make initial

Mini Case 6.6

Selection and Portfolio Management at SmithKline Beecham[43]

SmithKline Beecham, now GlaxoSmithKline, is a large pharmaceutical company. The merger that created the company five years before left them with a large R&D portfolio of more than half a billion dollars in 1994 which needed reorientation in the face of new pressures. Management were unhappy that their selection process appeared to have become politicized as strong-willed project leaders competed for resources for projects that only they fully understood. The process was seen as neither efficient nor objective. As one manager said 'Figures can't lie, but liars can figure'. The problem was to install a process that was much more open and objective and that could gain the support of all concerned. Their improved approach had three phases.

The first was to ask teams to make not one but four proposals: a base-line proposal, to continue the project as planned; a 'buy-up' proposal in which they could ask for larger resources for an enhanced project scope or speed; a 'buy-down' proposal for smaller scope; and a 'minimal' that would close the project but retain the maximum benefits. This had the effect of moving teams away from 'all or nothing' advocacy towards a more business-centred approach. These new proposals were discussed with senior managers and with the group who would later form the selection panel. In a number of cases the teams themselves, or the subsequent discussions, produced new approaches that were better than the single track to which the team had become committed. The selection panel now understood all the projects well and were clear that the best routes to success had been chosen.

In the second phase, a common set of information was compiled about each project with the help of consultants and colleagues inside and outside the project. Valuations

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were produced using decision trees and resulting in an upper and a lower valuation for each project rather than a single-point valuation. These valuations were reviewed and debated by the selection panel until everyone was content. Only then was the portfolio selected, and this was done by an independent internal consultancy group who then presented it to the selection panel for review. The selection panel could now concentrate on the portfolio debate, without getting drawn back into valuation issues.

The process is reported to be very successful. The careful and open valuation process was accepted as fair. Many projects were changed to the Buy up or Buy down proposal and the new portfolio projected a 3-fold improvement in return on assets. As a result, management agreed to increase overall R&D expenditure by 50 per cent.

estimates alone which are then discussed anonymously in a structured meeting where the aim is to understand the facts and reasoning. Then participants re-do their estimates and the average is taken, though also noting any serious outlying views. Particular care is needed in eliciting views of project risks and we discuss this further in Chapter 7.

The second people issue arises because innovation necessarily involves waste. A few years of effort that leads nowhere may be no problem for a company, but it will be a lot for the individuals concerned, especially as they often get to feel passionately about their work. This means that the selection process must be as open and objective as possible so that the inevitable disappointment when a project is cancelled does not turn into general disillusionment. It must also give credit to people who do good work on unsuccessful projects, otherwise the pool of innovators will surely dry up. Research laboratories do this by allowing their scientists to publish papers so that they can build a reputation for the quality of their work. At the very least project teams should be able to present and defend their innovation ideas directly to senior management so that they know they have received a fair hearing and that their work is understood and valued by their seniors. Many companies – Richardson Sheffield (Mini Case 6.7) is one, Philips is another – hold well-publicized exhibitions in which new ideas are promoted and top managers discuss and debate the proposals with the innovation teams before making decisions. Innovation is risky, but the risk must be borne by the company, not individuals.

Mini Case 6.7

Richardson's Knives[45]

Richardson Sheffield now part of the House of Fraser manufactures kitchen knives and scissors. Until fairly recently the company's success was primarily based on one main product range: the 'Laser' knife. With its fine serrated edge profile, this product had a 25-year 'stay sharp' guarantee. The Laser with its patents provided the company with a technological advantage that enabled it to grow dramatically throughout the 1980s.

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In recent years new entrants to the market, weakening intellectual property rights, and the growing importance of 'fashion' in all kitchen products had started to weaken the company's position.

MAJOR PROBLEMS

One of the key issues facing Richardson was that the company had adopted a strategy of giving every major retailer exactly what they wanted, no matter how difficult the variations were. As a result, David Williams, group technical director for McPherson's, who owned the company at the time, explains: 'We had ended up with an increasing number of customer-specific variations – and enormous business complexity, and all within a block of business that actually had not grown at all. We realized we had to stop clinging to old technology and an old definition of what constituted "customer service"'.

The main R&D department had increasingly become overloaded, and one-off special designs were pushing out core product development. Even when an early filtering system was set up, it was far too bureaucratic. The NPD process itself suffered from many typical problems; in particular there was no 'front-end' coordination and control, and no real R&D focus. 'Instead of focusing on major projects, we used to start and develop many projects, and then cherry pick the best ideas for final design', explains Williams. 'Many ideas almost got to market before being dropped, because only right at the end did we get any marketing input'. Also, decision-making was very slow and poor. 'All major project decisions were taken by the Group's senior executives at regular business review meetings', notes Williams. 'R&D was only one item on the agenda at these reviews – and usually the last one. Consequently decisions were often rushed, with executives dismissing ideas and re-directing projects without proper consideration'. Also, the reasons why some projects were chosen in preference to others were not transparent to most of the organization, as only those present at the business review meeting were informed.

Another key problem was a poor understanding of the market and consumers. As with many companies that grow through technological dominance, and with products that effectively sell themselves, Richardson Sheffield had lost contact with its customers. As its technological lead diminished, the company found it increasingly difficult to develop new products that met consumers' expectations.

THE INNOVATION PROCESS

The changes to managing innovation at Richardson Sheffield were summarized in the company's Three-Stage Model: this consists of a front-end process, the NPD process, and tooling to production process. The pre-development 'front-end' is based around a process framework developed by Williams. 'Essentially the first key ingredient was to establish that there was only one process ...and all projects should follow this route, and be subjected to the same filter screens – no more product extensions, or projects being completed by the back door route', he says. To enforce this, marketing has become the originator of all new product projects, and works jointly with R&D to develop product ideas that can be presented to retailers as a combination of technology, consumer and customer-driven concepts, rather than simply asking what retailers want.

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A key part of this approach is the offline development of new technology. 'We have found in the past that it is very difficult to get new technologies to work, and impossible to say when the technology will be ready. So we have formalized the approach whereby I keep the technical developments on one side, only pushing them forward when they are ready', explains Williams. 'Once I have proved the material technology, and if I can sell the benefits to the marketing people – and through concepts to the customer – then the technology is taken up and developed into a full project brief. This way customers are not left waiting for promised new technology, and from the market's point of view the development cycle from them seeing a technology to the finished product is very short'.

For all projects that are to be progressed, the company now appoints a new product manager – from within marketing – who is made responsible for that project, and who works directly with the R&D team once they are given the brief. The coordinated work up-front ensures that only those projects which are likely to have a high market impact come into R&D for development. 'R&D no longer gets bombarded with hundreds of half-baked and badly thought through ideas', notes Williams. To enforce this, full authority for specific projects has been delegated to the marketing product managers and the development teams. Projects no longer have to be continually assessed by senior executives.

'Development projects are now very much in the hands of the marketing product managers. Therefore projects are much less likely to be "political solutions" – a design which tries to harmonize all the division's requirements and customer demands into one product, which often led to products that did not really meet anyone's requirements', says Williams. He adds: 'The senior executive review now only looks at future product strategy rather than specific projects, and this was again something that we dramatically needed to achieve'.

Selecting the Tools

We have already observed that the financial tools used in evaluating individual projects must be chosen to fit the complexity and risk involved, and that scoring systems may change as projects mature. In the same way, the tools and methods used for evaluating portfolios need to evolve as the projects progress, from the broad and subjective methods in the early stages towards 'hard', financial analysis later on. For example, if we imagine a project that starts in a research laboratory and makes its way eventually to a commercial product the choice of portfolio management tools may evolve as indicated in Figure 6.13.

In the very early stages the only important thing is to identify some possibilities that excite enough interest to motivate the team. Later on, scoring methods and risk-reward assessments help, but in the final stages most companies would expect fully costed business plans.

The team that does this review must be in a position to take the necessary actions so it will generally be at a divisional or corporate level in order to have the scope and power to do the job. There is, however, some debate about whether portfolio reviews should generally be conducted together with those for individual projects, or separately. Cooper[46] advocates that project reviews should be

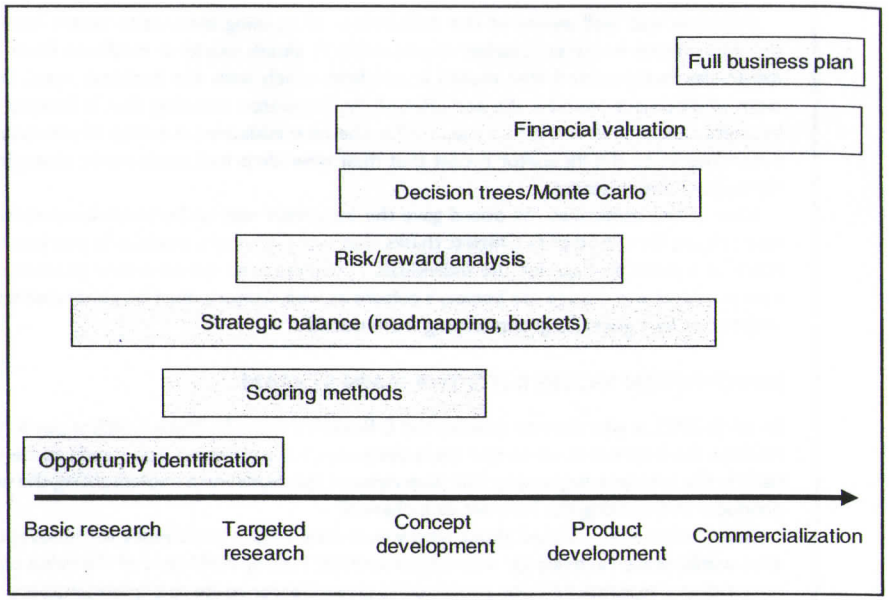

Figure 6.13 Appropriated selection tools at various stages of the innovation process

conducted at times required by the work programme and not constrained to an artificial timetable. Hence portfolio reviews should be separate. However, good communication between the processes is essential; one would not wish to give a project the go-ahead at its project review only to have it axed by the portfolio process the next day.

SUMMARY

Selecting and managing the portfolio of innovation projects are difficult but vital parts of managing innovation. Failure to make good and timely decisions is bad for efficiency in the short term, and for profit, or even survival, in the long term. In this chapter we have reviewed a variety of techniques to help managers select the innovation projects to pursue:

- Financial methods of varying degrees of sophistication take centre stage, but they must be backed up by more subjective methods that allow strategic and other factors to be included in the analysis.
- Particular care is necessary in valuing risky projects. It is a mistake to use single estimates of value such as the mean. The range of possible outcomes must always be considered.
- Scoring systems are particularly helpful in the early stages of projects when financial information may not be reliable.

- The portfolio of projects selected must not only represent the best possible use of resources, but must also be balanced in terms of risk, timing and strategic impact.
- No one set of tools suits all situations; the choice depends on the information available, the type and complexity of the projects involved and how close they are to commercialization.

RECOMMENDED READING

1. Bernstein, P. L., *Against the Gods: The Remarkable Story of Risk* (New York: John Wiley, 1998). [An excellent and readable account of the history and ideas of risk and risk management.]
2. Boer, F. P., 'Financial Management of R&D', *Research-Technology Management*, Vol. 44, No. 4 (July 2002), pp. 23–34. [Good survey of the available methods for valuing innovation projects.]
3. Sharpe, P. and Keelin, T., 'How SmithKline Beecham Makes Better Resource Allocation Decisions', *Harvard Business Review* (March–April 1998) pp. 3–10. [Best practice for a disciplined and inclusive management process.]
4. Cooper, R. G., Edgett, S. J. and Kleinschmidt, E. J., *Portfolio Management for New Projects* (Cambridge, MA: Perseus Books, 2nd Edition, 2001). [A complete and authoritative review of portfolio management practices.]

MANAGEMENT RECOMMENDATIONS

- Choose project valuation tools that are appropriate for the types of project: using subjective measures such as scoring when uncertainty is high, but emphasizing financial measures more as commercialization approaches.
- Keep valuation tools simple and transparent so that the decision process remains open to review, and leaves scope for management judgement.
- Treat numerical measures of risk with caution; they are always very approximate.
- Avoid point forecasts; try and understand the range of possibilities open to each project.
- Ensure that the portfolio is balanced in terms of time and strategy.
- Give close attention to the management process, ensuring that the valuation process is objective and that unsuccessful innovators are rewarded for their efforts.

CASE STUDY

Britannia Building Society – Building and Evolving a Portfolio Management Process[47]

Before reading this case study, consider the following generic innovation management issues:

- What are the difficulties a company faces when it tries to create an innovative culture where one did not exist before?
- Can innovation be imported into an organization from outside or must it grow from within?

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- How does innovation management differ in service and manufacturing enterprises?
- What criteria are appropriate for evaluating projects in the service sector?

The Britannia is a building society (the British equivalent of a Mutual Fund), founded in 1856 in Staffordshire in the north of England. It provides mortgages, loans, related insurances, savings and investment products. The Society's traditional values of reliability, accessibility and personal service served it well for many years and innovation was not high on the agenda.

THE 'SKUNK WORKS'

The arrival of the Internet in the 1990s caused a shift in Britannia's attitude to innovation, and in 2000 a special task force, the 'E-Business Unit', was set up to explore the opportunities and threats it posed, and to promote higher levels of innovation in general. Within this team a subgroup, called 'The Incubator', was given the task of generating new product possibilities and pushing them forward. The team operated as a 'skunk works', in a separate location, away from the day-to-day running of the business. The E-Business Unit was headed by Tim Franklin, who reported directly to the then Group Chief Executive, Graham Stow.

Mark Chizlett, the programme coordinator, approved of this organization: 'Skunk works teams are focussed, fast and open to innovation. In a very disciplined, data-rational, company like ours we needed a team with some independence and the ability to experiment with running new products; and with a real sense that it is OK to fail.' The Incubator team worked closely with the Board, initially in a three-month intensive strategy review, and later by regular meetings every three months to review projects and manage the portfolio.

From the start the team used a process with four gates to ensure that good ideas were selected and that the balance of projects was appropriate:

Gate 1: Presentation of ideas and decision on which to take forward;
Gate 2: Review of solutions and decision whether to do a controlled pilot, 'launch and learn';
Gate 3: Decision whether to proceed to a scale implementation;
Gate 4: Review of experience and decision to 'plant out' or sell off.

Review meetings started with a presentation of the existing portfolio and ended with a review of how it stood after the decisions just made. Projects that had reached a milestone were assessed and rated against a 'balanced scorecard' of criteria before being approved to move on. The criteria were different at each gate, being initially rather subjective but getting steadily more rational as the projects matured. Detailed financial analysis was not used, at least in the early phases. It was a learning experience for everyone. Chizlett says the Board were not always in their comfort zone: 'They were used to carefully-documented proposals full of data that had already been reviewed by other committees. But, with appropriate stakeholder management by Tim, they came to find the different approach refreshing and thought-provoking. And it worked: we completed six quite major new projects in the first two years'.

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Britannia was well aware of the deficiencies of running innovation teams outside the mainstream business. Chizlett commented: 'A skunk works is insulated from the day-to-day business and that means it can lose touch with the business case'. So a team of directors oversaw the activities of the Incubator, ensuring that it focused on business results and that it had support for the new initiatives. A policy of short-term secondments to the Incubator meant that their new ideas had ready-made champions throughout the business.

One of the objectives the board gave the Incubator was to be torch-bearers for a new culture for the Society. Chizlett thinks that was probably a mistake: 'It was just too much of a cross to bear for the individuals in the team: to set up a new process and new products and change the Society's culture as well. Culture must be generated from within, not by a guerrilla group sniping from outside'.

INNOVATION MOVES INTO THE MAIN STREAM

By early 2003, it was time to devolve the E-Business team. As Mark Chizlett put it 'We realised the Internet is no longer something new; it's something that needs to be put back in the business. Anyway, by this time most of the team were implementing the new products and running the Internet as a channel'

But Chizlett was worried about who would now be the 'conscience for innovation': who would search actively for new opportunities? Making NPD part of the value chain rather than a separate function promised to give a clearer route to implementation; and it was felt that the new product ideas would benefit from the insights of people further upstream, who were in regular contact with customers. An NPD mission statement expressed the need very clearly: 'If we don't respond quickly to new products from the competition our members (customers) and prospective members will take their business to those that do, limiting our ability to meet targets and strategic ambitions'.

Britannia would be a fast-follower in innovation, a stance driven by both their brand values and resources.

The arrival of a new Group Chief Executive, Neville Richardson, in 2003 provided a trigger for a more concerted move to change the culture of the society and to embed NPD activities more directly in the fabric of the organization. The 'Living the Values' culture-change programme was headed and driven by Richardson. All staff attended a briefing and a roadshow followed by intensive training sessions, company publications and reinforced by new personal objectives. The new culture generated several new sources of ideas: all mangers now have continuous improvement goals in their objectives; the suggestions scheme was revitalized; and a route was created from the customer care department to NPD to feed in opportunities raised by customers.

The position of New Product Development as an integral part of the company was formalized in a new management process, launched in 2003. The NPD manager has the job of collecting propositions and ideas from throughout the company and selecting the most promising ones. A committee with representatives from Marketing, Treasury, IT, Administration, Finance and the Sales channels helps with the selection. The managing board, chaired by Tim Franklin, now the Managing Director of the Member Business and a main board Director, reviews the chosen ideas using a balanced scorecard of nine elements, illustrated in Figure 6.14. Individual members of the board themselves

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provide the scores for the projects, ensuring a high level of consistency from project to project.

ELEMENT	WEIGHT	MANAGER RESPONSIBLE FOR SCORING
Benefits	4	Marketing *and* Finance
Customer need	3	Customer Excellence
Strategic fit	3	Marketing
Business risk	4	Product Management
Systems and processes	3	Information Services
Operational complexity	3	Operations *and* Sales
Delivery cost	4	Finance
Dependencies	3	Information Services
Priority	3	Managing Director

Figure 6.14 Britannia's project scoring system

'I don't say that what we've done would be right for everyone but it's right for us, here, now', says Chizlett, now promoted to manage the Savings and Investments division, 'There will still be conflicts, compromises, choices. We'll start some things and have to stop and try again. But the conditions for success are all well in train.'

7 IMPLEMENTING INNOVATIONS

There is nothing more difficult to take in hand, more perilous to conduct nor more uncertain in its success, than to take the lead in the introduction of a new order of things.

Nicolo Machiavelli

INTRODUCTION

Turning an idea for an innovation into reality is bound to be something of a unique experience that must be treated as a *project*: a finite activity with its own objectives and resources, and above all its own leadership.

Successful implementation of an innovation starts with good *Project Management*, nowadays properly regarded as a professional discipline in its own right. No project of any size has much of a chance without a well-trained project manager with the power to get things done and the support of higher management. He or she will need good people skills because the more innovative the project is the more impact it is likely to have on people not directly involved in the project itself and this often generates resistance. Managing the reactions of the various stakeholders who are affected is a particularly important job for the manager of an innovation project.

New Product Development (NPD) is the most frequent type of innovation project for most companies, and most of best practices in innovation management have their origins in the development of new hardware or software products. But innovation projects of all types share the basic problem of NPD: managing complex projects that demand learning and experimentation on the route to a novel result. This chapter is about this management problem.

Implementation is shown at the end of the innovation funnel in the Pentathlon framework but this does not mean that it is a separate activity that follows on after ideas have been collected and a selection decision made. The Ideas and Selection phases may involve investigations, trials and pilot studies which may be thought of as early parts of the implementation process. Certainly they require similar management techniques. In such projects what is learned at each stage