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Project Portfolio Tools – Anatomy and Pathology

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Abstract

Portfolio management methods and tools are widely used to ensure that resources are best deployed to achieve organisations' strategic goals. This paper focuses on the particular 'matrix' representation that lies at the heart of portfolio management. Many variants of these simple frameworks have been developed, supporting the analysis of a range of strategic issues. Surprisingly, however, few studies have examined the nature of these tools, and consequently there is a lack of underpinning theory concerning their function and structure and limited guidance on their effective development and deployment. This working paper summarises the findings of a preliminary investigation of this widely adopted but little studied area, with particular reference to the structure and application of this class of management tool.

1.0 Introduction

Selecting and managing a portfolio of strategic projects is a critical management concern for many firms, typically as part of their strategic planning and new product development processes. A combination of weighted scoring and 2x2 matrices (Fig. 1) is commonly used to support decision making, with the visual nature of the matrix providing a useful communication aid.

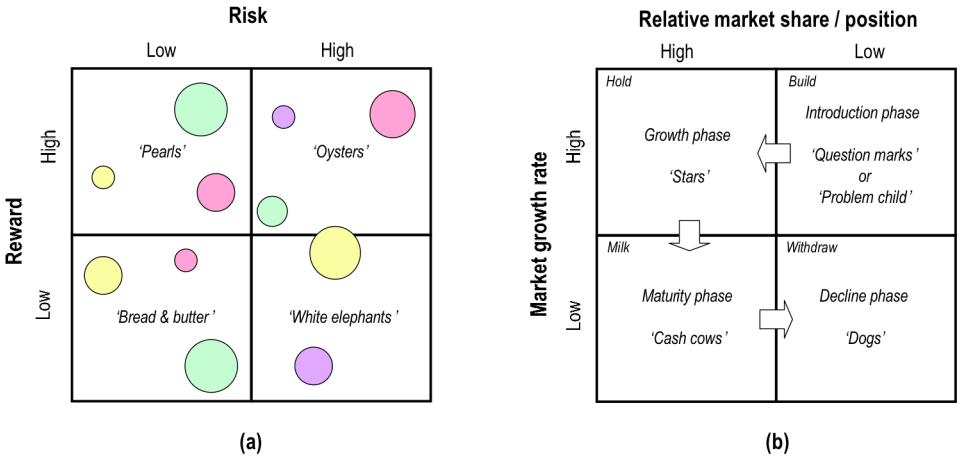

Fig. 1 – Two well-known examples of portfolio matrices: a) AD Little risk-reward matrix (Cooper et al., *1997), and b) Boston Consulting Group (BCG) business activities portfolio matrix (Johnson & Scholes, 1998)*

Two-dimensional matrices are an attractive and popular management tool, as their ubiquitous appearance in management texts and MBA courses attests. Their popularity arises in part from the visual impact that supports and guides dialogue, and partly from their flexibility to support a range of management objectives:

1) Comparison and selection of strategic options and opportunities, at business, product and technology levels.
2) Guidance on identifying appropriate particular strategic actions, such as whether to 'make or buy'.
3) Balanced allocation of resources.
4) Performance assessment of projects and investments.

Portfolio methods can be applied at both project (product and technology) and strategic (business) levels. Both of these are considered in this paper, although the emphasis is on project portfolio management, with particular reference to the selection and management of research, technology and development projects.

More than forty examples of portfolio matrices have been collected (see Appendix A), providing a resource for investigating their nature. Their apparent simplicity masks a number of subtleties. It is clear from even a cursory glance that many express very similar ideas in different words. Some provide a rich analysis of possibilities while others do little other than state the problem in visual terms. There is a clear need to better understand the concepts that underpin their development and application and hopefully to provide a guide to more effective design.

The spatial representation offered by a matrix is a great aid to discussion and communication even when the tool offers little more than display. Many psychologists have pointed out (Pinker, 2007) that spatial metaphors are deeply embedded in the human mind and directly affect the way we think (thus the past is 'behind' us; problems are 'large' or 'small', and new ones may 'appear over the horizon'). So it is no surprise that it is often helpful to show issues in spatial terms. However, a well-designed matrix can do much more than merely provide an aid to reflection.

To describe a business issue in terms of only two variables is always a simplification. In practice many more than two factors are likely be relevant and a full graphical representation of them would require many dimensions. However, the human mind cannot intuitively grasp more than 3 - and any more than 2 are difficult to show on paper - so there is a natural tendency to draw in two dimensions. Nevertheless, the hidden factors that are not displayed must not be forgotten. This is not a merely academic point because, as we show below, the influence of factors other than those plotted on the axes is precisely what makes a matrix tool useful.

A recent book by Lowy and Hood (2007) is entirely devoted to the subject of 2x2 matrices, giving numerous examples and case studies. Although such matrices are widely used, there appears to be a gap in terms of both theory and practice. The conceptual foundation is not clearly understood, and there is great diversity in how they are applied. The proliferation of approaches resulting from companies, consultants and academics has led to a situation which can be confusing for an organisation seeking to implement such methods.

Section 2 of this paper provides an overview of portfolio management, with the structure of matrix tools as applied to portfolio selection addressed in Section 3. The wider context of portfolio management in business is explored in Section 4, in terms of its role in strategic planning and new product development, and how it relates to other key tools and techniques. Some key principles for

the development and application of portfolio matrices are summarised in Section 5, and areas where further research is needed are identified in Section 6.

2.0 Management of project and product portfolios – overview

Cooper *et al.* (2001) identify the following three principle goals for product portfolio management (which can be extended to the more general challenge of 'strategic option' portfolio management):

1) *To maximise the value of the new product project portfolio* (against one or more business objectives, such as profitability, strategy, acceptable risk, etc.), resulting in a rank-ordered list of projects. Cooper *et al.* describe a number of approaches: financial measures such as Net Present Value (NPV) / bang for buck; Expected Commercial Value (ECV); the productivity index (PI); options pricing theory (OPT); checklists; and weighted scoring against multiple criteria.
2) *To achieve a balanced portfolio of new product projects* (for example, in terms of scale, timing, markets served, customer needs, business areas, risk / reward, capacity utilisation). The main approach recommended by Cooper *et al.* is the use of portfolio matrices, or 'bubble diagrams' (typically a 2x2 matrix, the axes of which may be derived from scoring methods), incorporating dimensions such as: risk vs. reward, market vs. technical risk and external vs. internal impact.
3) *To ensure alignment with business mission, vision and strategy,* ensuring that company strategy is clearly represented in the factors considered in the above two areas. According to Cooper *et al.,* strategic alignment can be achieved through top-down approaches (allocating a certain proportion of resources to each business goal or area; or simply giving priority in funding to selected strategic initiatives) starting with vision, goals and strategy, identify suitable product initiatives and/or resource allocations, using for example product roadmaps or 'strategic buckets'); or bottom-up approaches (giving strategic criteria high weighting in the criteria used for selecting projects) using a project selection method to screen opportunities identified); or a combination of top-down and bottom-up.

Building on the work of Cooper *et al.,* Goffin and Mitchell (2005) identify the purpose of portfolio management as being to ensure that at any time the company's collection of innovation projects makes the best use of its resources and will deliver the best value to the company over time. This view emphasises the key issues of 'resource allocation' and 'time' (considered further in Section 4), which are fundamental to the strategic management of innovation. More specifically, Goffin and Mitchell (2005) identify two key challenges facing managers concerning the allocation of resources to innovation projects (which are likely to be at different stages of their life cycle, and associated with different levels of uncertainty):

1) Deciding which projects are intrinsically worth doing in themselves (the *valuation problem*).
2) Choosing a group, or portfolio, of them that best meets the overall needs of the organisation (the *balance problem*).

3.0 Structure of portfolio matrices

3.1 Overview of matrix-based tools

2x2 matrices can, of course, be used for a wide variety of purposes (Lowy and Hood 2007). The focus for this paper, however, is their use as a portfolio management tool; that is to say as a tool for appraising a collection of activities, either existing or proposed, and suggesting or guiding the actions to be taken. The activities may be projects, products, investments, even business units; in what follows we will use the generic term 'projects'. Often the action will be to choose some and

discard the others. Clearly the whole process is driven by the positions (or at least the relative positions) of the projects on the matrix and so the value of the tool depends on the positioning being done effectively. Interestingly, one often finds matrix tools being proposed with little or no definition of how the axes should be interpreted. We believe that rating or scoring systems for placing projects in the two dimensions is an implicit part of these tools and should be clearly defined.

The structure of this management tool is explored in the sections below, based on the collection of examples in Appendix A. Phaal *et al.* (2006) have analysed the broader class of 'matrix-based' tools of which the portfolio matrix is a special type. The examples in Appendix A were extracted from a large collection of 850 such tools. They define the class of 'matrix-based tools' as:

> *"Relatively simple two (or sometimes more) dimensional orthogonal structures, relating key dimensions of the particular management issue being addressed. The axes are divided into categories, or define variables that may be qualitative, quantitative, discrete or continuous in nature. The matrix may contain text, providing information or guidance structured by the axes and associated categories, or may be 'empty', enabling the user to explore the relative positioning of various options, or the relationships between the key dimensions and categories".*

3.2 Portfolio matrix dimensions

The portfolio matrices in Appendix A show many common features, albeit described in different words. Table 1 shows that 29 out of 41 matrices appear to be examples of only three basic pairings, with the remaining 12 being more diverse:

1. Company *strength* vs. innate *attractiveness* of the opportunity
2. Perceived *risk* vs. anticipated *reward*
3. Company's *technology strength* vs. *business strength*.

Table 1 – Portfolio matrix axis dimensions

#	**Company strength**	vs.	**Innate attractiveness of the opportunity**
TP-1	Business position		Market growth attractiveness
TP-5b	Company's relative strength		Technology maturity
TP-7	Technology capability		Competitive impact
TP-9	Company's position		Technological attractiveness
TP-19	Technology position		Technology maturity
SP-1	Competitive position		Industry attractiveness
SP-2	Relative market share		Market growth rate
SP-5	Company's competitive position		Prospects for market sector profitability
SP-6	Competitive position		Maturity of industry
SP-10	Corporate strengths		Market attractiveness
SP-11	Business unit strength		Industry attractiveness
SP-12	Strength of assets and competences		Market attractiveness
SP-13	Competitive position of firm		Market attractiveness
SP-14	Capability		Market attractiveness

#	**Perceived risk / uncertainty**	vs.	**Anticipated reward**
TP-3	Technical probability of success		Market share
TP-12	Probability of technical success		Potential value (given tech success)
TP-14	Time to launch		NPV
TP-15	Probability of development and scale-up		Net present value

	success		
TP-17	Probability of technical success		Reward
SP-8	Goal posts (near, far)		Pay-off
SP-9	Risk		Reward
SP-17	Ease of implementation		Market/concept attractiveness
SP-19b	Level of anticipated rivalry		Contribution to company profit

#	**Company's technology strength**	vs.	**Company's business strength**
TP-2	Technical capability		Market strength
TP-4	Technical competence		Market competence
TP-8	Competitive technology position		Competitive business position
TP-10	Relative technology position		Relative business position
TP-11	Technology attractiveness		Market attractiveness
TP-18	Technology risk		Market risk

#	**Other: Dimension 1**	vs.	**Other: Dimension 2**
TP-5a	Company's absolute strength		Company's relative strength
TP-6	Technology maturity		Competitive impact
TP-13	Expected additional expenditure		Shareholder value
TP-16	Relative expenditure		Market share
TP-20	Relative technology position		Premarket / postmarket
TP-21	Competitive advantage		Benefits to customer
SP-4	Performance compared with competitors		Importance of competitive criteria
SP-7	Profit per unit sold		Market share
SP-18	Strategic intent		Market segments
SP-19a	Contribution to profit		Contribution to revenues
SP-19b	Profit contribution		Revenue growth rate
SP-19d	GNP per capita growth rate		Business sector relative growth rate

Even when the duplications are removed several distinctly different tools are discernible and the question arises whether some structure can be found which links them and perhaps throws some light on whether some pairings are to be preferred to others. In other words is there a useful taxonomy for such tools and does it lead to guidance on best practice?

At the highest level of analysis the potential value of a project to an organisation can be regarded as a combination of the size of the *opportunity* that is available to the organisation, and the degree to which the organisation may be able to grasp it ('*appropriability*').

Roughly speaking, the attractiveness of the activity is the product of these two factors:

$$\text{Attractiveness} = \textit{Opportunity} \times \textit{Appropriability}$$

$$A_t = O \, x \, A_p$$

The multiplication sign indicates that both factors must be present at some level to make an opportunity viable (attractive) – neither is adequate in itself. These two factors may be further analysed into constituent factors such as:

- *Opportunity:* market size; market growth; technology maturity; competition; sector profitability; industry maturity market attractiveness.

- *Appropriability:* technology strength; market strength; competitive strength; business strength; market share; ease of implementation.

These two perspectives combine to form a generalised portfolio (selection) matrix, shown in Fig. 2, which is compatible with the most common types in Table 1. For example, financial reward and risk (AD Little matrix) form constituent parts of the more general concepts of opportunity and appropriability.

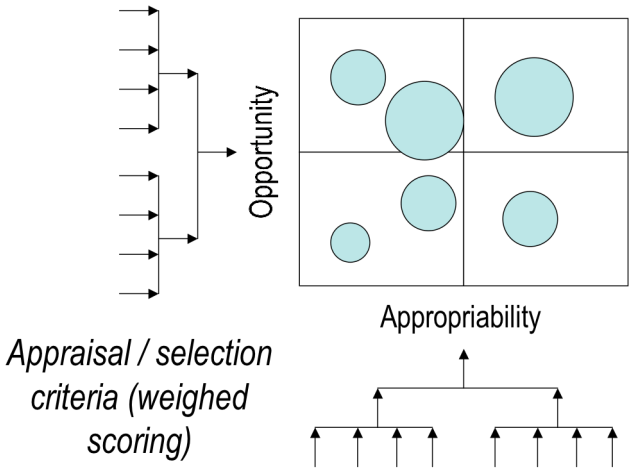

Fig. 2 – Generalised selection portfolio matrix (opportunity vs. appropriability), highlighting hierarchical weighted scoring criteria

The value of this class of portfolio matrices as far as selection is concerned is primarily one of visual impact, because the content is essentially symmetrical: the attractiveness is high when both are high, low when both are low and intermediate in between. The two dimensions add no extra selection information beyond what would be provided by a list of activities in order of O x A_p.

However, it may often be easier to improve the appropriability (by enhancing the organisation's capabilities) than to alter the innate size of the opportunity, and so financial constraints might even make the O-A_p matrix non-symmetrical in some cases.

The O-A_p diagram is clearly related to the well-known SWOT analysis framework (Strengths, Weaknesses, Opportunities, Threats). Opportunities and threats are positive and negative factors that contribute to assessing *opportunity* while strengths and weaknesses are positive and negative contributors to appropriability.

Most matrix tools consist of two-dimensional plots of pairs of such constituent factors, sometimes both from the same list, sometimes with one from each. In any case, the position of projects on the diagram requires a value on each axis. Since the axis variables are usually themselves quite complex the assumption is that these values are obtained by some kind of multi-factor scoring system, as illustrated in Table 2. Even when numeric figures such as market share or expected profit are available these will generally involve a multi-factor analysis, for example across market sectors or product types. In any case the value of the matrix tool is compromised unless the scoring or valuation system is made explicit, as highlighted in Fig. 2.

Table 2 – Du Pont's project scoring matrix (Cooper et al., 1997)

	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-$20 M	< $5 M

In general, portfolio matrices may become unsymmetrical, and so useful for more than display purposes, when used to plot factors at a lower level of abstraction. The factors plotted may both come from the opportunity or from the appropriability list, or one from each. The constituent factors are generally additive in that a low level of one may be compensated for by a higher level of another; no individual constituent factor is essential. Clearly, each constituent factor may also be analysed into sub-constituents, resulting in a weighted scoring system that aggregates factors relating to both the scale of the opportunity and the organisation's ability to appropriate (A_p) the opportunity (O), to estimate the relative attractiveness (A_t) of the project or strategic option:

$$A_t = \Sigma O \; x \; \Sigma A_p$$

3.3 Implicit Variables

A matrix tool is essentially a plot of one or more quantities that are a function of the variables on the axes and so vary in some useful or interesting way across the plane. Lowy and Hood refer to this as a 'tension' between the variables. The display would be meaningless without this although, interestingly, the implicit quantity concerned is seldom mentioned explicitly (it would be better if it were). Sometimes there is more than one implicit variable so that the display presents several different aspects of the subject simultaneously. This gives a richness to the picture, although at the expense of a lack of precision unless (as is seldom the case) these variables are clearly identified. The concept of the implicit variable is illustrated in Fig. 3.

In project portfolio work the implicit quantity is often the value of the project, and the display shows how this depends on the axis variables. A very common case is where the value is reckoned to be the sum or product of the axis variables. Here the project value can be thought of as a plane rising smoothly from, say, the bottom left to the top right corner. The display shows which are the most attractive projects (the ones closest to the top right corner); and gives a visually compelling display of the state of the portfolio. The value of the visual impact may be considerable but the information might equally well be shown by simply listing the projects in the order of the sum, or product, of the axis variables. We call this case a 'one dimensional' matrix and it can be detected most easily by noting that if strategic advice is given in the four quadrants it tends to be of the rather bland type shown in Fig. 4. Examples TP4, TP10, SP1, SP11, and less obviously TP2, TP9 and SP12 are of this type. The well-known McKinsey matrix (where the axis variables are market attractiveness and business strength) is also an example.

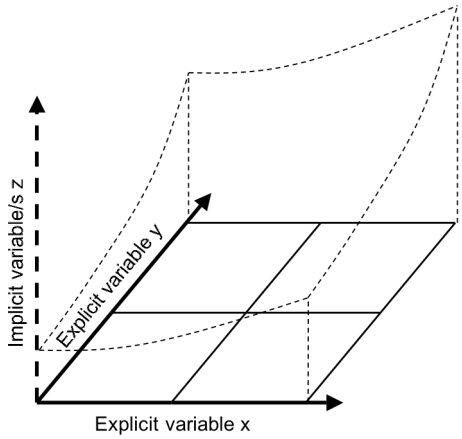

Fig. 3 – Portfolio matrix, showing implicit ('hidden') variable

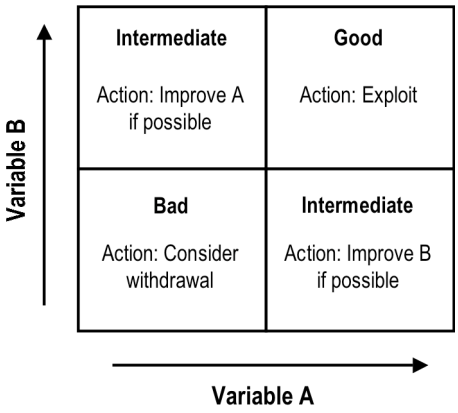

Fig. 4 – A 'one dimensional' matrix in which the implicit variable (for example project value) is the sum or product of the axis variables A and B

A more interesting case is where the implicit variable is a resource that is in finite, or at least restricted, supply that has to be balanced across the portfolio. A well-known example is the Boston Consulting Group (BCG) matrix (Fig. 1b) in which the axes are market growth rate and the company's market share. The major implicit variable (there is actually more than one) is cash flow. This is positive for the 'cash cows', negative for the 'problem children' and neutral or uncertain for the 'stars' and 'dogs'; so the ideal collection of projects is one which is spread over the plane - not just clustered over in the top corner - so that the positive and negative cash flows may balance out over the portfolio, illustrated in Fig. 5.

The BCG matrix is also an example of a tool with several implicit variables. The others, again seldom mentioned explicitly, are the current and, especially, the future contributions that the elements of the portfolio are expected to make to the business. Indeed, the only reason a business would include projects with a negative cash flow into the portfolio is because of their future prospects are expected to be better than those of the existing elements, illustrated in Fig. 6.

The AD Little risk-reward matrix (Fig. 1a) is another example where there are more than one implicit variable. Here the expected project value (if successful) is plotted against risk, generally

understood as the probability of success or failure. The implicit variables are the exposure to loss (or the value at risk) represented by each project and the potential future benefit to the company. These are similar to the axis variables, but not identical to them, as Fig. 7 shows.

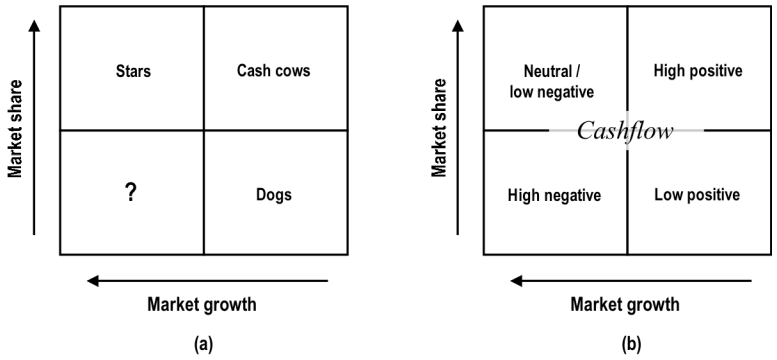

Fig. 5 – The Boston Consulting Group (BCG) matrix, showing a) standard form, and b) the chief implicit ('hidden') variable, cash flow

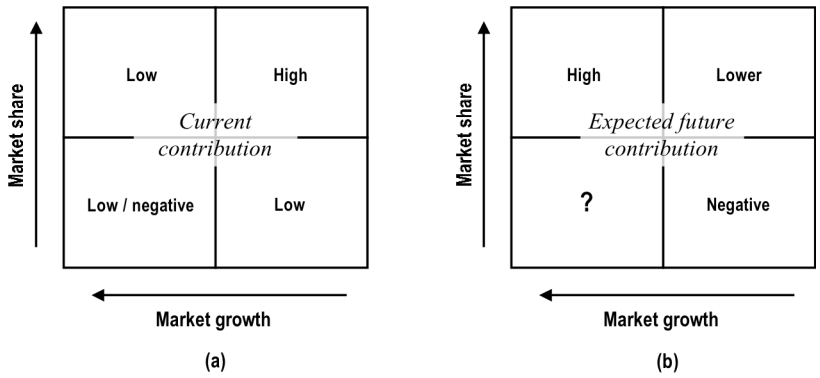

Fig. 6 – The other two implicit variables of the Boston matrix: a) current contribution and b) expected future contribution to the business

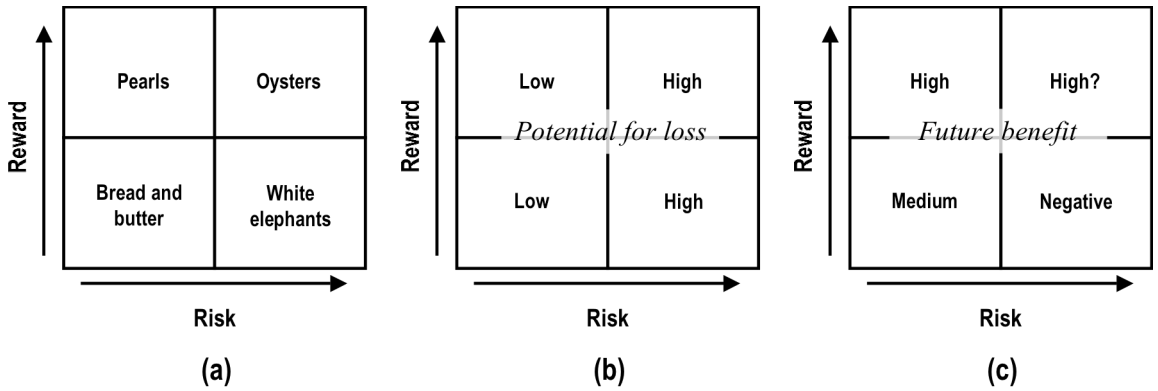

Fig. 7 – AD Little Risk-Reward matrix: a) standard form, b) first implicit variable: potential for loss, and c) second implicit variable: future benefit

3.4 Resource as the implicit variable

In all the examples of portfolio matrices we have examined the implicit variables are resources available to the enterprise to conduct its business. Three broad types can be distinguished:

1) Liquid (*primary*) resources that can be redirected quickly such as: cash, investment funds, most kinds of equipment, and some skills.
2) Partially liquid (*secondary*) resources that can be changed, but only slowly. Examples include specialist skills that are in short supply, business structures like partnerships, supply chains and distribution networks, and possibly brand image
3) Illiquid (*tertiary*) resources. The most obvious of these is time, the fundamental and unalterable resource available to any enterprise. An enterprise that aims to continue must cater for both the immediate and the longer term future; and since time itself cannot be re-distributed, striking a balance between the demands of the present and the future is probably the most fundamental issue that organisations face (the issue of time is discussed further in Section 4).

In any commercial organisation great attention is rightly given to the deployment and application of primary resources. They typically appear as the variables, or the measures of the variables, in portfolio matrices. The secondary, and especially tertiary (time), resources are often implicit variables.

3.5 Treatment of uncertainty and risk

Risk often appears as a factor in portfolio tools. The AD Little risk-reward matrix is a well-known example and others are given in Table 2. The term may refer to the outcome of the project as a whole ('project risk') or to individual aspects such 'commercial risk' and 'technical risk'). We distinguish four senses in which risk may be used:

1) As a numeric measure of the spread of possible outcomes about the mean (such as standard deviation).
2) As a measure of the value at risk. This means the amount of money or other resources the organisation stands to waste in the worst outcome of the project.
3) As a measure of the probability of 'failure'.
4) As a general indication of difficulty (broadly equivalent to appropriability).

It clearly matters very much which sense is intended; yet in practice the meaning is very often left wholly or partly undefined. A project may rate very differently according to which definition is used . For example a project may have a high probability of failure but the value at risk may be very small if the uncertainty can be resolved quickly and cheaply, or very high if the risk of failure persists until later, when large sums have been committed.

4.0 Portfolio management in the business context

Management tools and frameworks, such as portfolio matrices, should not be considered in isolation from the business context within which they are developed and deployed. Of particular importance are the business processes within which such tools operate, and the goals that they are intended to serve, such as improved understanding, communication, decision-making and performance measurement, together with the links to other tools and frameworks used. This section focuses on the relationship between portfolio matrices and business processes (new product introduction / innovation and strategic planning), and the roadmapping approach that is frequently used as an integrating mechanism within these processes.

Figure 8 shows a schematic process 'funnel', which is often used to represent innovation and new product development / introduction, and is also applicable to strategy development and implementation. Also shown in Fig. 8 is the way in which one particular management tool, roadmapping, can provide a common integrating framework throughout such processes. Roadmaps are useful in this role due to their integrating holistic structure, typically comprising a number of layers (e.g. functional perspectives) set against time, providing an organising structure for the visual representation of strategy at all levels. However, the content of roadmaps, and the process for developing roadmaps, are very different for the left-hand 'front end' of the process compared to the right-hand 'back end'.

At the front end the emphasis is more on exploration, in order to understand the strategic context and to identify and assess potential strategic opportunities and options, while later on the emphasis shifts to planning and implementation. In a similar way, portfolio methods and matrices can be used throughout such processes, but must be adapted to reflect the context (i.e. more light weight, exploratory and qualitative at the front end, and more robust and quantitative later on, often associated with business case development). Typically, such processes include review points (e.g. stage gates within a new product introduction process, or budget allocation within an annual strategy cycle), where methods such as portfolio matrices and roadmaps are used to support decision-making and budget allocation.

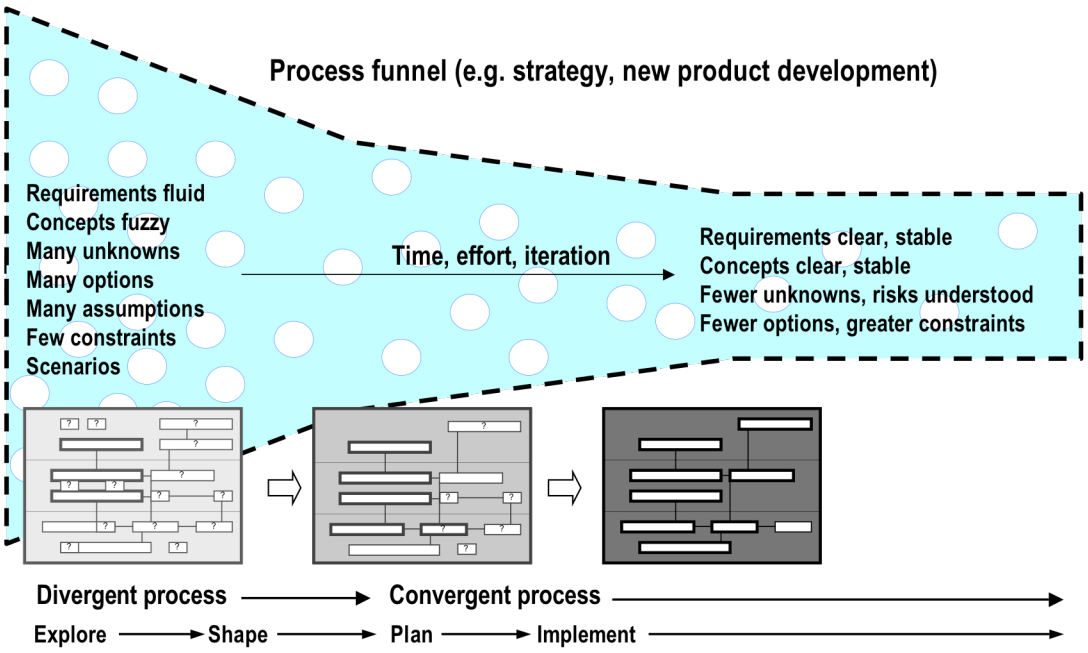

Fig. 8 – Innovation, new product development & introduction and strategy processes are often represented using a 'funnel' metaphor – roadmaps can provide a common integrating framework throughout such processes, supported by portfolio matrices to aid decision making and budget allocation

Time is an important factor in innovation and strategy, as it takes time to innovate; the market and competitive environment evolves; the future is uncertain and forecasts are unreliable; time to

market is important; time costs money (e.g. DCF); and technology and product developments and activities need to be aligned. A strength of the roadmapping approach is that time is typically an explicit variable, while for portfolio matrices time is usually not shown explicitly, although it is often an important implicit variable. Opportunities often lie in the future, while strengths and weaknesses typically reflect the current situation. This is particularly true for research portfolios, as it takes time and effort to develop technology to the point where it is sufficiently mature for insertion within product development programmes.

The general relationship between roadmaps and portfolio matrices is shown in Fig. 9, building on the 'scalable' architecture provided by roadmaps, which can apply at both the business and product / project levels:

a) Portfolio roadmaps are high level (e.g. business unit or corporate) visual representations of how the range of projects, products and options that a company might invest in can achieve its strategic goals. For example, Albright and Nelson (2004) describe how roadmaps form a central part of balanced portfolio management.
b) Portfolio matrices show the same projects and options that are depicted on the portfolio roadmap (projects and options, at product or technology levels), but emphasising selection criteria or other measures / perspectives to support decision-making.
c) Option (or project) roadmaps are lower level roadmaps that show the detail behind each 'bubble' in the portfolio matrix.

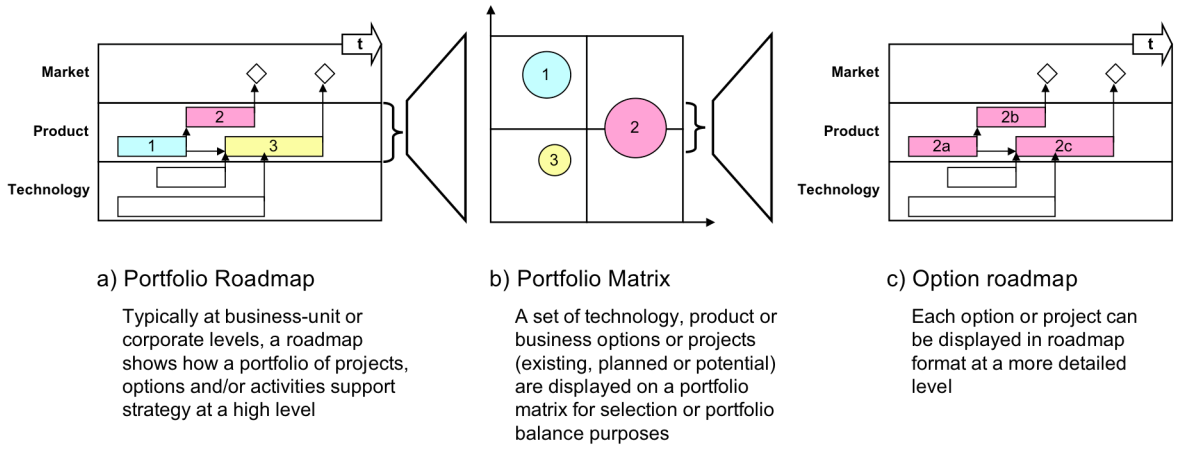

Fig. 9 – Relationship between portfolio methods and roadmapping (making time explicit)

Portfolio management and roadmapping should be used in conjunction to build a more complete understanding of strategic opportunities and options, along with other tools (e.g. QFD for linkages, which can also apply at the portfolio and project level), as part of a scaleable integrated toolset, aligned with strategy and innovation processes (Dissel *et al.,* 2005, Phaal *et al.*, 2006b).

5.0 Principles of good design and application

Brady et *al.* (1997) define a management tool as "a document, framework, procedure, system or method that enables a company to achieve or clarify an objective". The term 'management tools' in the broadest sense includes devices for supporting both action and conception (achievement and clarification, as defined by Brady *et al.*). More precise definitions for related terms such as 'tools', 'techniques', 'procedures', 'processes', 'models', 'maps' and 'frameworks' are provided by Phaal

et al. (2004), with tools relating to practical application and frameworks to conceptual understanding – of course, approaches such as portfolio matrices can server both purposes.

Brown (1997) and Farrukh *et al.* (1999) list some principles of good practice for tool design – tools should be: founded on an objective best-practice model; simple in concept and use; flexible, allowing 'best fit' to the current situation and needs of company; not mechanistic or prescriptive; capable of integrating with other tools, processes and systems; result in quantifiable improvement; and support communication and buy-in. Hunt *et al.* (2004) identify desirable characteristics of management tools, with particular reference to the valuation of technology: accuracy, including the principle that the precision of the tool should match the precision of the available input data; easy-to-use (balanced against the need for accuracy); intuitive, supporting the generation of understanding; widely applicable and scalable; credible and accepted.

Portfolio matrices should be designed with the above general principles in mind. The approach will often need to be customised to suite the particular situation, to ensure that appropriate matrix axes are selected for the intended purpose, and that the relevant measures are used for the weighted scoring system. However, further work is required before detailed guidance can be provided, as described below.

6.0 Conclusions and hypotheses

This working paper presents the findings of a preliminary study of a widely used but not very well understood management tool – the portfolio matrix. While apparently simple, there are subtle and hidden factors that underpin the approach conceptually, and affect its effective deployment. A number of contributions have been made:

1) Identification of a generic form for portfolio matrix when used for selection purposes: opportunity vs. appropriability.
2) Recognition of implicit ('hidden') variables often associated with portfolio matrices.
3) Clarification of the relationship between portfolio matrices and their business context (links to business processes and other tools – in particular roadmapping).

This area would benefit from further work, to better understand the various types of portfolio matrices (in the context of this general class of matrix tool), in terms of their underlying principles, design and deployment. Improved theory and guidance in this area would have a positive impact on both innovation and strategy in industry.

To this end we propose the following principles and hypotheses, based on the work so far, as worthy of further study:

1) Any valid portfolio matrix tool requires a clear definition of the axis variables and a scoring system for determining where projects should be placed on each axis. Thus scoring systems and portfolio matrices are intimately linked.
2) The most general portfolio matrix is Opportunity-Approbriability (O-A_p). The elements used in scoring for each axis include all the things that contribute to the attractiveness of the project. The axes of the O-A_p matrix are independent and so the overall attractiveness of the project is represented by the product of the scores for O and A_p.
3) The useful portfolio tools are those where the axis variables are linked by one or more implicit variables that are important in the portfolio. Such a tool helps managers to balance or allocate these factors between the projects. The implicit variables may be imagined as a third dimension of the matrix.

4) Hypothesis 1. The implicit variables are the most important factors in designing a portfolio matrix tool. They should always be made explicit. Where there is more than one implicit variable separate matrices should be drawn.
5) Hypothesis 2. The implicit variables are always resources.
6) Hypothesis 3: All portfolio matrices are made by plotting two components selected from the O and A_p scoring lists
7) Hypothesis 4: The components of the O and A_p scoring lists can be analysed into a hierarchy of elements. This implies that there will also be a hierarchy of matrices. Study of this should further illuminate the theory of portfolio matrices

7.0 References

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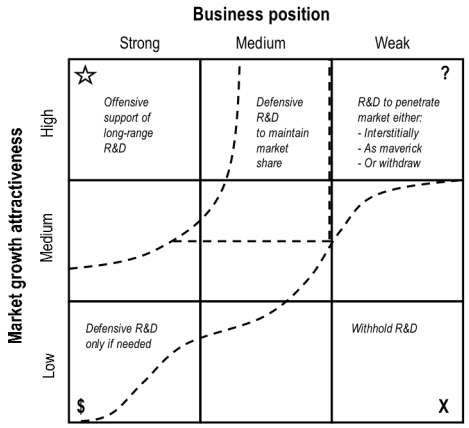
Appendix A – Portfolio Matrix Catalogue

The porfolio matrices in this Appendix have been extracted from the T-Cat management tool catalogue (www.ifm.eng.cam.ac.uk/ctm/t_cat), which contains more than 850 management tools and frameworks, predominantly of the 'matrix' or grid types, covering a wide range of management topics. The catalogue was compiled in 2000, and organised by topic into sets of about 20, two of which relate to portfolio management (general business strategy, and technology strategy).

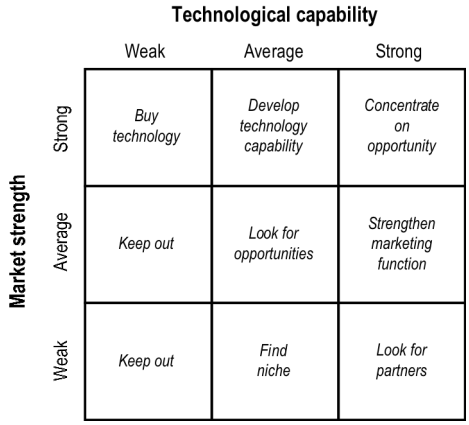


R&D strategy matrix in a multi-product company

Identifier: TP-1

Description: This matrix provides a means for understanding and selecting appropriate research and development strategies, depending on the attractiveness in terms of potential market growth, and the relative business position of the firm. See also Frohman & Bitondo (1981) for simplified version.

Reference: Frohman & Bitondo (1981), cited in Twiss, B. (1992), Managing technological innovation, 4th Ed., Pitman Bitondo, D. and Frohman, A. (1981), 'Linking technological and business planning', Research Technology Management, November, pp. 19-23.

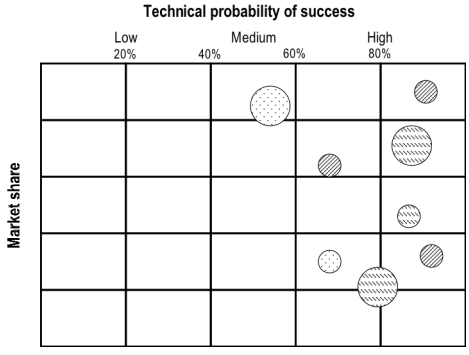


Technology – market strategy matrix

Identifier: TP-2

Description: This matrix provides a means for understanding and selecting appropriate technology and market strategies, depending on the relative market strength and technological capability of the firm.

Reference: Lowe, P. (1995), The management of technology: perceptions and opportunities, Chapman & Hall, London.

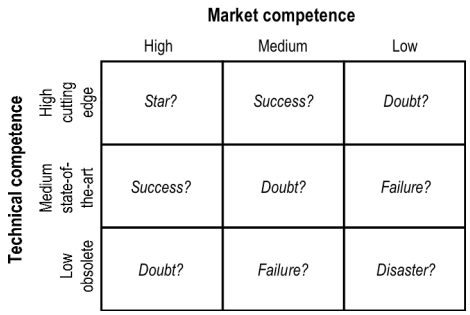
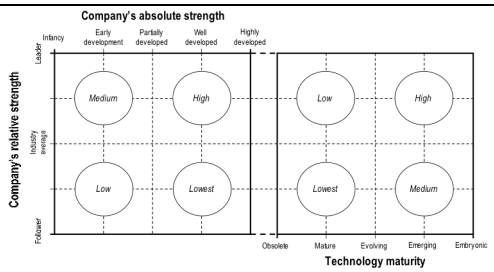
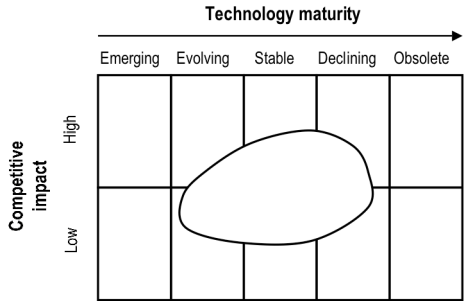
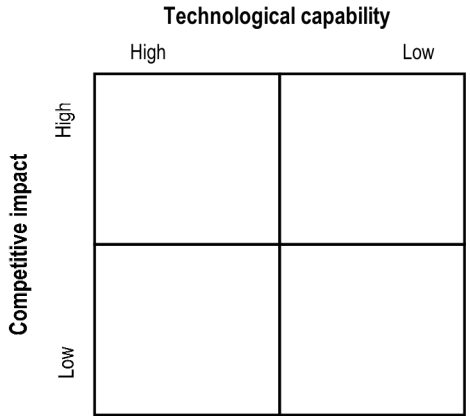


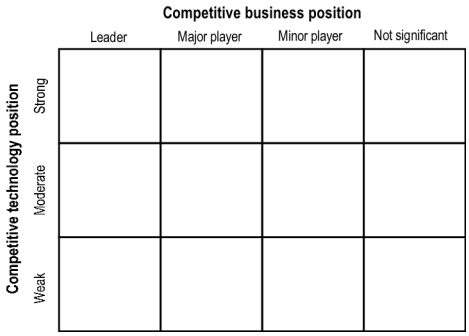
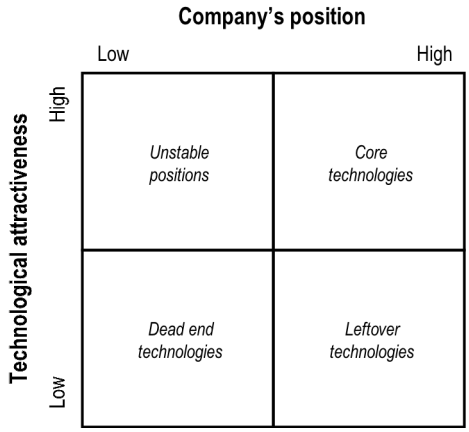
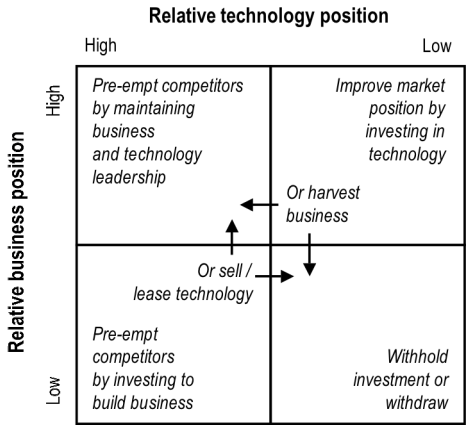
Technology probability of success vs. market share

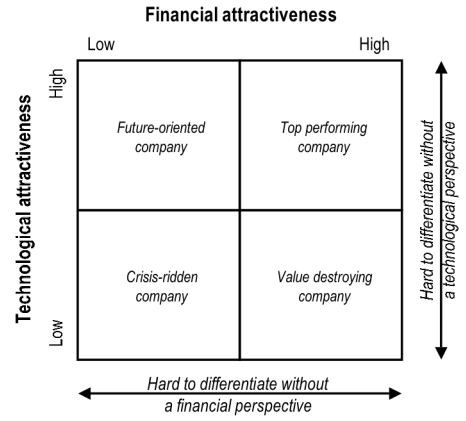
Identifier: TP-3

Description: This matrix supports portfolio management of new product development and R&D projects, based on the probability of technical success and anticipated market share. The size of the bubbles indicates cost (including capital expenditure, R&D resource investment and innovation expenditure), while the shading indicates different types of projects.

Reference: Ganguly, A. (1999), Business-driven research & development - managing knowledge to create wealth, Macmillan Press, Basingstoke.

	Market – technology matrix for analysing technical and product competence Identifier: TP-4 Description: This matrix, originally proposed by Holt in 1990, can be used to analyse the technical and marketing competence necessary to support strategic decision making in product innovation. Reference: Khalil, T. (2000), Management of technology - the key to competitiveness and wealth creation, McGraw Hill, Boston.
	Critical capabilities – core technical competences Identifier: TP-5 Description: These grids have been developed to support a process for defining core technical competences (current and future requirements). The process involves the identification of critical technological capabilities, which are clustered and assessed to form competence areas, using the grids, on the basis of the company's technological strength (absolute and relative), and technology maturity. Clusters that lie in the 'high' quadrants are most likely to represent core competence areas. Reference: Gallon, M.R., Stillman, H.M and Coates, D. (1995), 'Putting core competency thinking into practice', Research Technology Management, 38(3), pp. 20-28.
	Technical portfolio matrix Identifier: TP-6 Description: This matrix allows the portfolio of technologies within the business to be assessed in terms of their competitive impact and maturity (i.e. age / life cycle), enabling the 'balance' of the portfolio to be assessed. Reference: Dussauge, P., Hart, S. and Ramanantsoa, B. (1992), Strategic technology management: integrating technologies into global business strategies, John Wiley & Sons, Chichester.
	Technical portfolio matrix Identifier: TP-7 Description: This matrix allows the portfolio of technologies within the business to be assessed in terms of competitive impact and capability, enabling the 'balance' of the portfolio to be assessed. Reference: Dussauge, P., Hart, S. and Ramanantsoa, B. (1992), Strategic technology management: integrating technologies into global business strategies, John Wiley & Sons, Chichester.

	Techno-business position matrix Identifier: TP-8 Description: This matrix provides a means for supporting business and product portfolio management, in terms of both the technological and business position of the company, relative to competitors. Reference: Lauglaug, A.S. (1987), 'A framework for the strategic management of future tyre technology', Long Range Planning, 20, pp. 21-41.
	Technology portfolio matrix Identifier: TP-9 Description: This matrix provides a means for supporting understanding and selection of resource allocation strategies for technology programmes, using a portfolio approach, based on the technological attractiveness (i.e. importance in value creation), and the position of the company relative to competitors. Reference: Jolly, D. (1998), 'Revisiting technology portfolios using the resource-based approach', Proceedings of the 7th International Conference on Management of Technology, Orlando, 16-20 February, pp. 1005-1014.
	Technology implementation strategies Identifier: TP-10 Description: This matrix, adapted from Nemec (1981), provides a means for understanding alternative technology implementation strategies, based both on the relative technology and business position. Reference: Lauglaug, A.S. (1987), 'A framework for the strategic management of future tyre technology', Long Range Planning, 20, pp. 21-41.

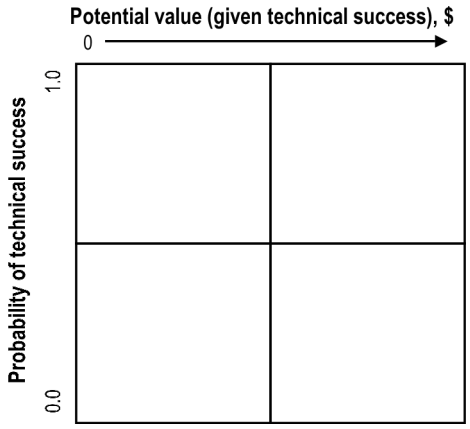


Technological and financial portfolio

Identifier: TP-11

Description: This matrix provides a portfolio assessment approach for supporting investment decisions, based on both financial and technological considerations (attractiveness). Hartmann proposes methods for assessing financial and technological attractiveness, on the basis of a conventional financial balance sheet approach, combined with a 'technology balance sheet', which includes products, processes and technology (internal and external).

Reference: Hartmann, M.H. (1999), 'Theory and practice of technological corporate assessment', International Journal of Technology Management, 17(4), pp. 504-521.

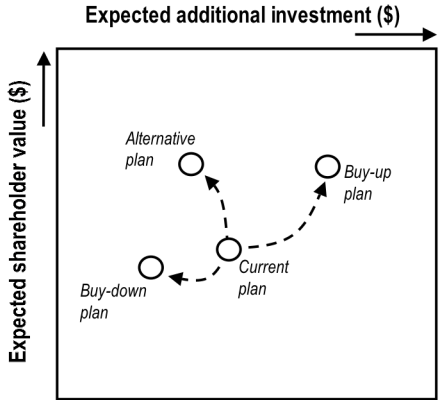


Project portfolio matrix

Identifier: TP-12

Description: This matrix supports project portfolio management, on the basis of both the probability of technical success, and the potential value (given technical success).

Reference: Menke, M.M. (1999), 'The diverse personalities of portfolio management: variations on a theme', Proceedings of Portland International Conference on the Management of Engineering and Technology (PICMET99), Portland, July, pp. 428-437.

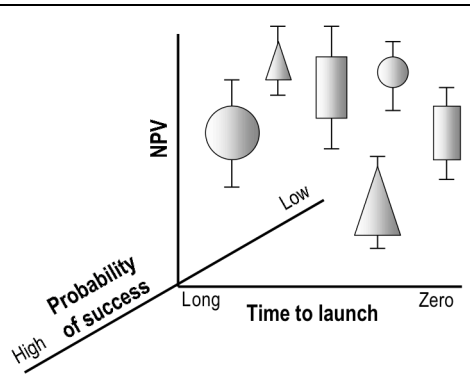
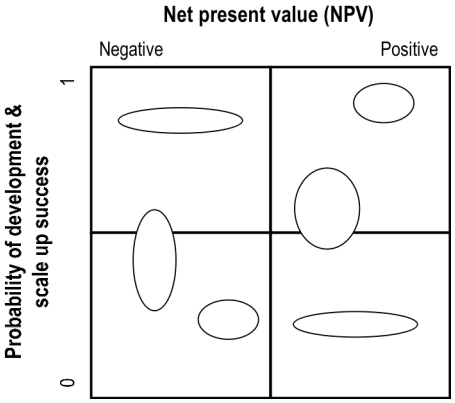
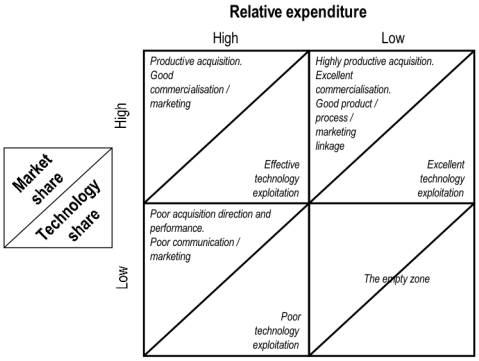


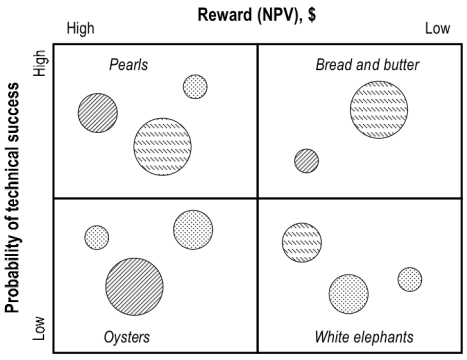
SKB options resource-allocation grid

Identifier: TP-13

Description: This grid supports the SmithKline Beecham approach to investment portfolio management, which is based on an 'options' approach, where current and future technology investment opportunities are assessed on the basis of whether investment should be increased or decreased, or other options adopted, on the basis of both the expected additional investment and shareholder value.

Reference: Sharpe, P. and Keelin, T. (1998), 'How SmithKline Beecham makes better resource-allocation decisions', Harvard Business Review, March-April, pg. 50.

	Proctor & Gamble's 3D risk-reward bubble diagram Identifier: TP-14 Description: This matrix supports portfolio management of new product development projects, based on three dimensions: net present value, time to launch and the probability of success. The shapes denote the degree of technological fit with the company (i.e. competences, strategy, etc.): e.g. high, medium and low. The I-bars are used to indicate the possible NPD range (Proctor & Gamble use a Monte Carlo simulation to evaluate this range). Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1998), Portfolio management for new products, Addison-Wesley, Reading (Mass).
	3M project selection matrix Identifier: TP-15 Description: This matrix provides a means for assessing potential projects on the basis of both the anticipated return (in terms of net present value, NPV), and the probability of of development and scale up success. Larger circles and ellipses denote more uncertain estimates. Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1997), Portfolio management in new product development: Lessons from the leaders - 1, Research Technology Management, 40(5), pp. 16-28.
	The productivity of technological investment Identifier: TP-16 Description: Used to assess the overall performance of a company in exploiting technologies, in terms of 'productivity' of technological investment, in relation to competitors. Market share is the "proportion of total sales of products accounted for by the company's sales of product". Technology share is the "proportion of the productive use of a technology accounted for by the company through in-house application or sales of the technology to others". Relative expenditure is the "investment relative to competitors". Reference: Ford, D. and Saren, M. (1996), Technology strategy for business, International Thomson Business Press, London.

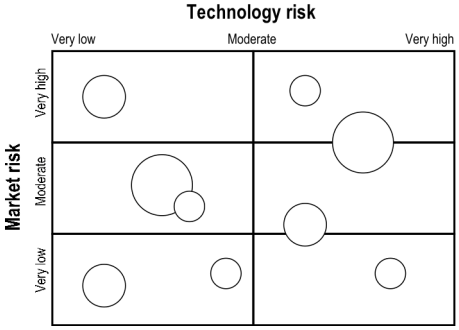


Risk-reward bubble diagram

Identifier: TP-17

Description: This matrix is a variant of the well-known risk-reward, adapted to focus on the probability of technical success, with reward determined by net present value. The matrix supports portfolio management of development projects, with the size of the bubbles representing resources, colour representing timing, and shading the product line. Cooper et al. report a number of variations of this matrix:
- AD Little's version includes both technical and commercial risk on the vertical axis.
- Speciality Minerals' version includes a general measure of the probability of success, together with a weighted measure of value (reward), which includes profitability and competitive advantage.
The four quadrants of the matrix define a set of decision rules: easy and important (go - budget resources for full development; important but difficult (go - use full resources and budget a research team); easy but less important (hold - do not budget resources, but 'cherry pick' from list of projects to fill holes in actual resource usage); and less important and hard (no go - do not resource).

Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1998), Portfolio management for new products, Addison-Wesley, Reading (Mass).

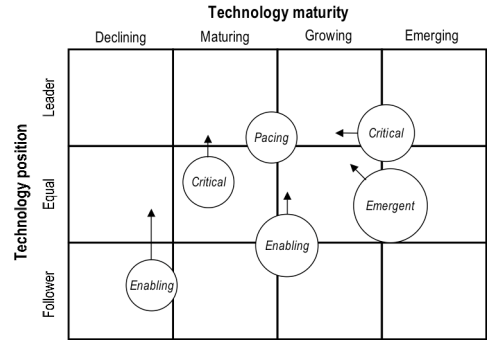


Market and technology risk bubble diagram

Identifier: TP-18

Description: This matrix supports portfolio management for R&D project management, and can be used for assessing other business opportunities and initiatives. The basis of assessment is risk, including both technological and market considerations. The size of the circles represents resources committed to each option.

Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1998), Portfolio management for new products, Addison-Wesley, Reading (Mass).

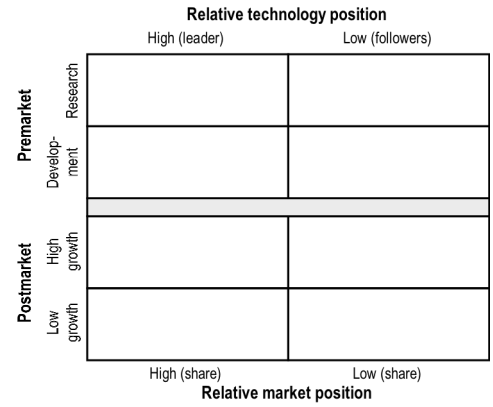


Technology portfolio map

Identifier: TP-19

Description: This matrix is a variant of a well-known technology maturity-position portfolio method, showing 'before' and 'after' positions for various scenarios or strategies. Particular technologies are plotted, indicating the impact of each technology (i.e. emerging, critical, pacing and enabling) with the size of the 'bubbles' representing investment levels.

Reference: Lindsay, J. (2000), The technology management audit - the tools to measure how effectively you exploit the technological strengths and know-how in your company, Financial Times / Prentice Hall, London.

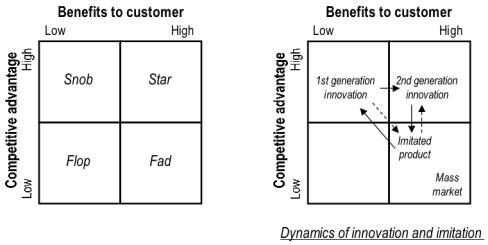


Technology portfolio

Identifier: TP-20

Description: This pair of matrices supports the management a technology portfolio, in terms of both 'premarket' (research and development) and 'postmarket' (level of growth), and the competitive position (for both technology and market).

Reference: Urbaniak, M. (20010), 'The meaning of technological innovation in business-to-business marketing', International Journal of Technology Management, 21 (5/6), pp. 628-636.

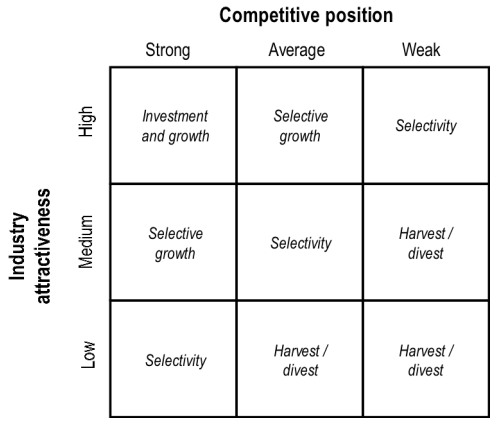


R&D project portfolio matrix

Identifier: TP-21

Description: This matrix supports the management of an R&D project portfolio, on the basis of both the competitive advantage and benefits to customer. "These criteria allow the matrix to portray not only the strengths and weaknesses of a firm, but also link its distinct capabilities to perceived customer satisfaction." The matrix has been used to support understanding of the dynamics of innovation and imitation.

Reference: Mikkola, J.H. (2001), 'Portfolio management of R&D projects: implications for innovation management', Technovation, 21 (7), pp. 423-435.

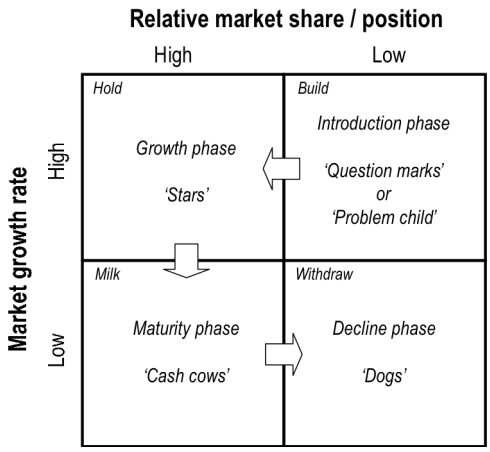


General Electric's business screen

Identifier: SP-1

Description: This matrix provides a means assessing the attractiveness of a business proposition, based on industry attractiveness and competitive position; it can also be used to assess the current business portfolio.

Reference: Brown, S. (1996), Strategic manufacturing for competitive advantage: transforming operations from shop floor to strategy, Prentice Hall, London, pg. 30.
Johnson, G. and Scholes, K. (1988), Exploring corporate strategy, 2nd Ed., Prentice Hall, New York.



BCG business activities portfolio matrix

Identifier: SP-2

Description: This well-known matrix, developed by the Boston Consulting Group, supports understanding of business activities and opportunities, in terms of both market growth rate and relative market position. Can be used for portfolio management.

Reference: Johnson, G. and Scholes, K. (1988), Exploring corporate strategy, 2nd Ed., Prentice Hall, New York.
Hood, D.D. (1991), 'The link between business strategy and technology development', Proceedings of the Portland International Conference on Management of Engineering and Technology, 27-31 October, pp. 721-726.
Chapelet, B. and Tovstiga, G. (1998), 'Development of a research methodology for assessing a firm's business process-related technologies', Journal of Technology Management, 15(1/2), pp. 10-30.

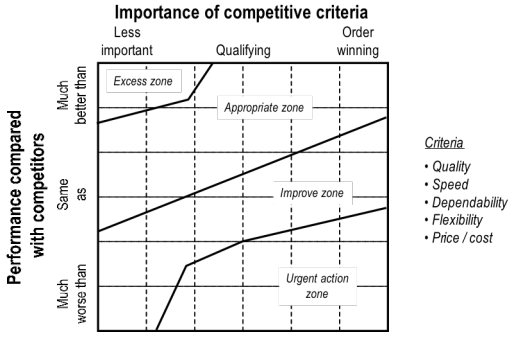
Issues / Quadrant	Strategic choice	Profitability	Required investment	Cash flow
Star	Hold / increase market share	High	High	Zero to negative
Cash cow	Add market share	High	Low	Very positive
Problem child	Increase market share or divest	None or negative	Very high	Negative or positive (divest)
Dogs	Divest / liquidate	Low / negative	Disinvest	Positive

Hax and Majluf's adaptation of BCG matrix

Identifier: SP-3

Description: This table builds on the Boston Consulting Group strategy matrix, focusing on issues within each quadrant: strategic choice, profitability, required investment and cash flow.

Reference: Twiss, B. (1992), Managing technological innovation, 4th Ed., Pitman Publishing, London, pg. 32.

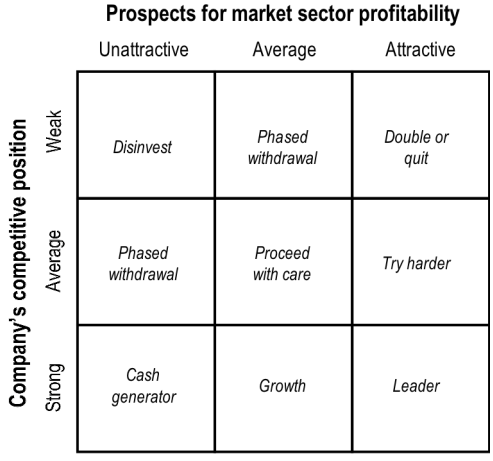


Importance – performance matrix

Identifier: SP-4

Description: This well-known matrix (proposed originally by Slack, 1991), provides a means for assessing the necessity and urgency of business action, based on both performance (relative to competitors), and the importance of decision criteria (e.g. quality, speed, dependability, flexibility and price / cost).

Reference: Prochino, P.J.L. and Correa, H.L. (1994), 'The development and implementation of a manufacturing strategy in Brazilian tin plated can manufacturer', Proceedings of the 1st Conference of the European Operations Management Association, 27-29 June, 27-29 June, pp. 131-136.

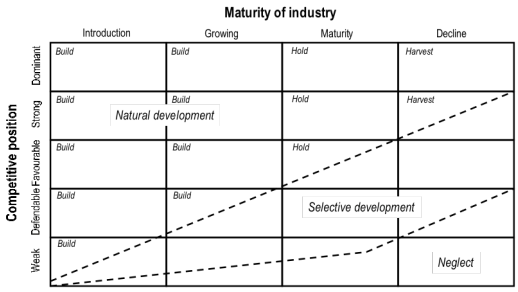


Shell's directional policy matrix

Identifier: SP-5

Description: This matrix supports understanding and selection of business strategy, on the basis of the company's competitive position and the attractiveness of the market.

Reference: Brown, S. (1996), Strategic manufacturing for competitive advantage: transforming operations from shop floor to strategy, Prentice Hall, London, pg. 30.

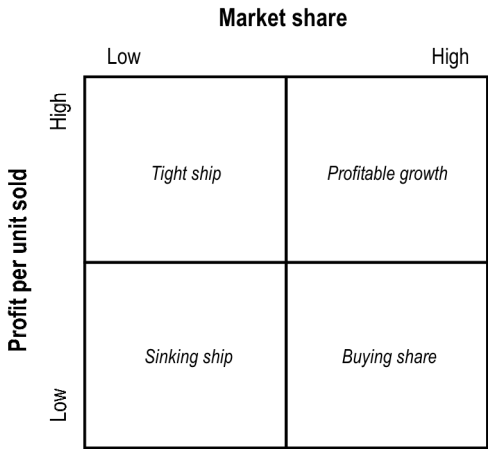


ADL strategic analysis model

Identifier: SP-6

Description: This matrix provides a means for understanding and selecting strategy on the basis of competitive position and industry maturity.

Reference: Hood, D.D. (1991), 'The link between business strategy and technology development', Proceedings of the Portland International Conference on Management of Engineering and Technology, 27-31 October, pp. 721-726.
Vernet, M. and Arasti, M.R. (1999), 'Linking business strategy to technological strategies: a prerequisite to the R&D priorities determination', Journal of Technology Management, 18(3/4), pp. 293-307.

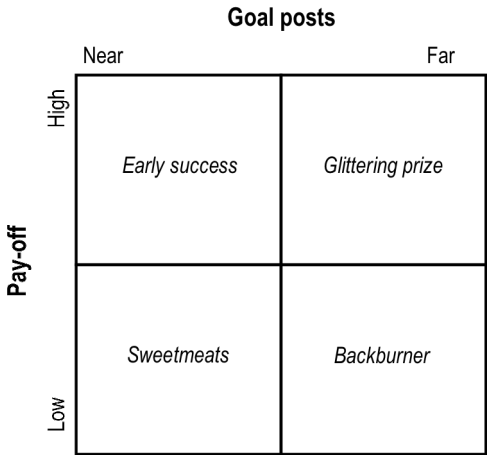


PA Consulting unit profit – market share matrix

Identifier: SP-7

Description: This matrix provides a means for assessing products (current and future) on the basis of both profit (per unit sold) and market share - both of which are important for assessing the attractiveness of a market or product.

Reference: Buckley, J.V. (1998), Going for growth: realizing the value of technology, McGraw-Hill, New York.

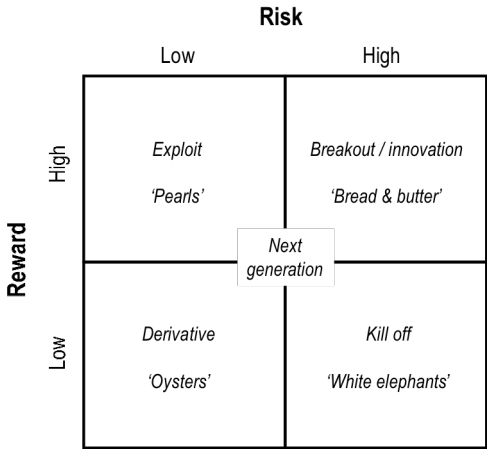


Risks and returns portfolio matrix

Identifier: SP-8

Description: This matrix supports the assessment of strategic options in terms of two key dimensions:
- "What is the pay-off of the proposed strategy, quantitatively, qualitatively or via a reasonable estimate of the benefit return?"
- "How far off are the goal posts in terms of the current capabilities, the business or technical difficulties to be overcome or the organisational barriers?"

Reference: Robson, W. (1997), Strategic management & information systems, 2nd Ed., Financial Times / Prentice Hall, Harlow.

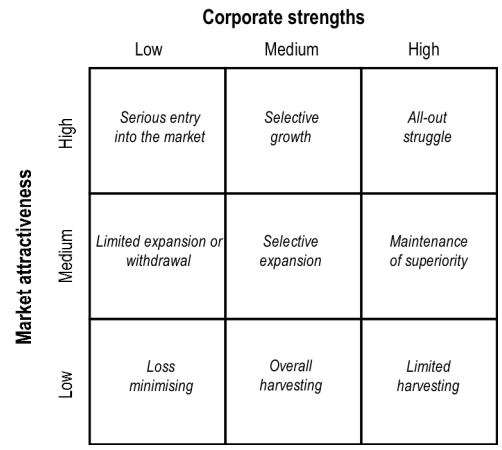


Risk – reward matrix

Identifier: SP-9

Description: This matrix provides a means for assessing projects / innovations / business opportunities, on the basis of anticipated risk and reward. Particular projects or opportunities are often plotted as 'bubbles' with the diameter of the bubbles representing cost or budget.

Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1997), Portfolio management in new product development: Lessons from the leaders - 1, Research Technology Management, 40(5), pp. 16-28.
Buckley, J.V. (1998), Going for growth: realizing the value of technology, McGraw-Hill, New York.

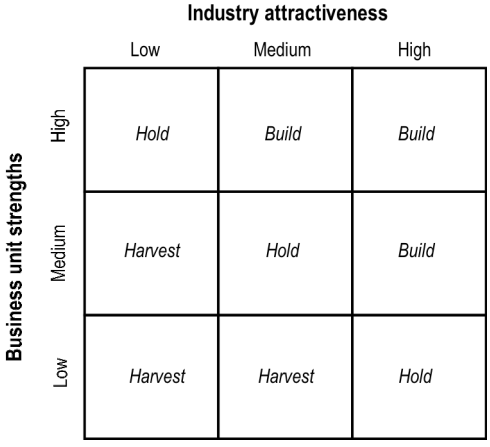


Ohmae's nine standardised strategies

Identifier: SP-10

Description: This matrix highlights general marketing / business strategies, depending on the market attractiveness and corporate strengths.

Reference: Ohmae (1982), cited in Harding, S. and Long, T. (1998), MBA management models, Gower, Aldershot.

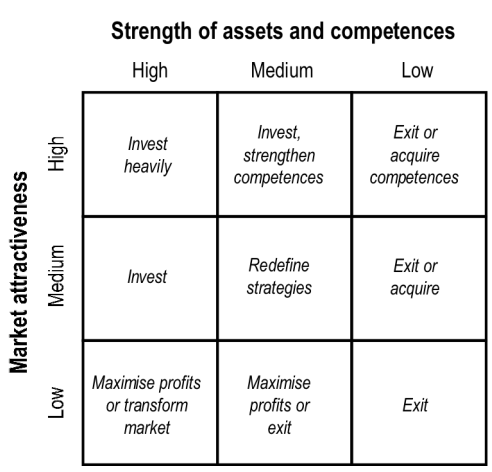


Company position – industry attractiveness screen

Identifier: SP-11

Description: This matrix provides a means for understanding and identifying investment strategies based on business unit strength (in terms of size, market share and technological standing) and industry attractiveness (in terms of market growth, size and profitability.

Reference: Hamerish (1986), cited in Harding, S. and Long, T. (1998), MBA management models, Gower, Aldershot.

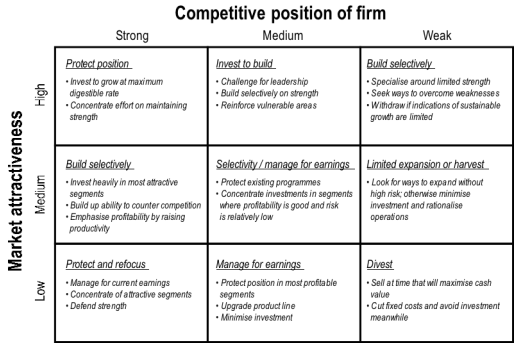


MAP analysis

Identifier: SP-12

Description: This matrix supports business strategy and portfolio management, on the basis of two key dimensions: market attractiveness, and the strength of assets and competences (e.g. skills, technology or capability).

Reference: Davidson, H. (1997), Even more offensive marketing - an exhilarating action guide to winning in business, Penguin Books, London.

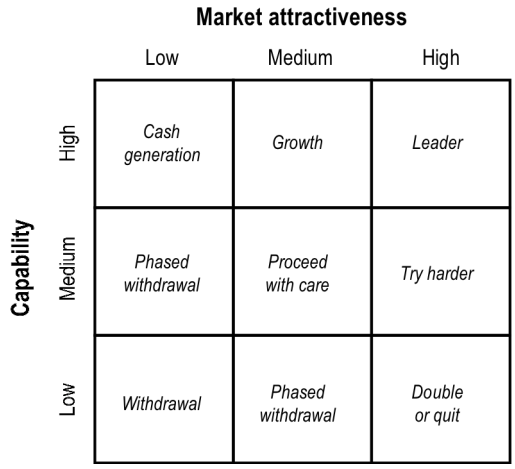


Market attractiveness / company capability portfolio matrix

Identifier: SP-13

Description: This matrix (proposed by Day in 1984) supports strategy and portfolio management, based on both the competitive position of the firm, and market attractiveness.

Reference: Adcock, D. (2000), Marketing strategies for competitive advantage, John-Wiley &Sons, Chichester.

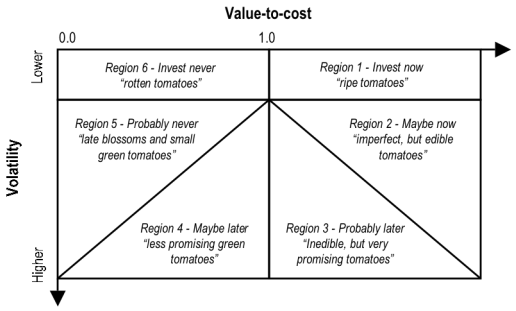
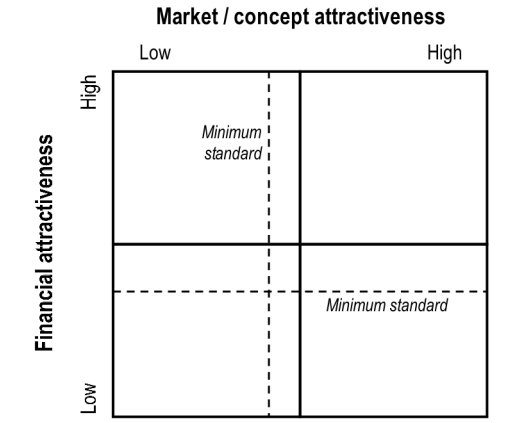
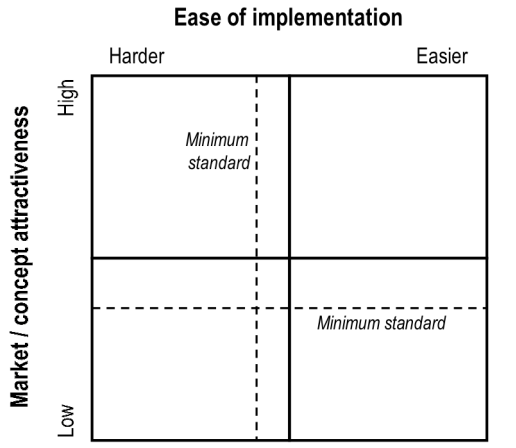
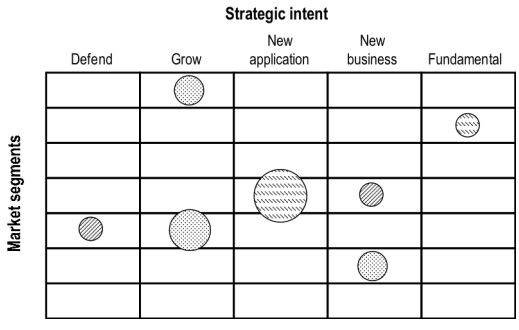


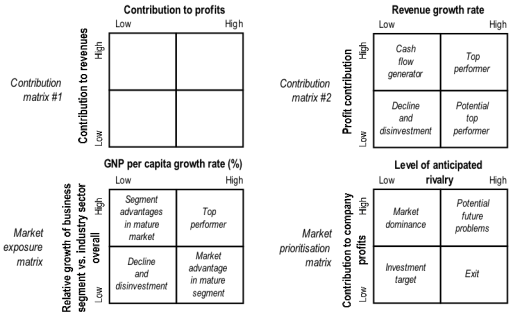
Capability – market attractiveness matrix

Identifier: SP-14

Description: This matrix provides a means for understanding and selecting business strategy on the basis of relative capability and market attractiveness (based on work by Kotler, 1996).

Reference: Ringland, G. (1998), Scenario planning: managing for the future, John Wiley & Sons, Chichester, pg. 63.

	Option space: 'the tomato garden' Identifier: SP-15 Description: This framework provides a means for supporting understanding and selection of investment strategy, based on options thinking. Option value depends on two parameters: value-to-cost and volatility, providing a means for assessing an opportunity now, and also taking a view of it's likely success in the future. Reference: Luehrman, T.A. (1998), 'Strategy as a portfolio of real options', Harvard Business Review, 76(5), pp. 89-99.
	Reckitt & Coleman financial – market / concept attractiveness matrix Identifier: SP-16 Description: This matrix provides a means for assessing business opportunities and initiatives using a portfolio approach, based on both attractiveness in terms of both financial and market / concept terms. Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1998), Portfolio management for new products, Addison-Wesley, Reading (Mass).
	Reckitt & Coleman ease of implementation – attractiveness matrix Identifier: SP-17 Description: This matrix provides a means for assessing potential projects on the basis of both the market / concept attractiveness and the ease of implementation. Cooper et al. report a similar approach adopted by the Royal Bank: importance vs. Ease of execution. Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1998), Portfolio management for new products, Addison-Wesley, Reading (Mass).
	Rohm and Haas strategic intent bubble diagram Identifier: SP-18 Description: This matrix supports project portfolio management, in terms of the markets that the organisation serves, together with the strategic intent (I.e. defensive, growth, new application, new business or blue-skies research). The size of the circles represents total cost, while the shading represents product lines. Reference: Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1998), Portfolio management for new products, Addison-Wesley, Reading (Mass).



Contribution of strategic business units

Identifier: SP-19

Description: This set of four matrices can used to compare the value of strategic business units, in terms of the (internal) contribution to both revenues and profits, and the (external) business position in the market.

Reference: Scott, M.C. (1998), Value drivers - the manager's guide to driving corporate value creation, John Wiley & Sons, Chichester.

Appendix B – Notes from roadmapping workshops

Project and option evaluation, prioritisation and selection of often form part of roadmapping workshops, although this is often done very quickly due to tiime constraints, drawing on expert judgement. However, in several workshops the factors that determine participant perception of value have been brainstormed, as listed below.

Aerospace #1 (2003)

Project excellence dimensions (raw, clustered)
- exploitability, continuity & diversity of funding, new market growth potential, partnership potential, time to positive income, progression rate, market leverage, future revenue
- knowledge continuity, capability maintenance, core capability development, develops customer base, protectable, competitive advantage, strategic fit, demonstrating innovation (image), innovative, positioning, leverage
- legal, environmental impact, national compliance, constraints, social acceptability, constraints on exportability, exit strategy, HSE
- risk reduction, commercial risk, technical confidence, technical risk
- cost to end of project
- team commitment
- (+ issue of ensuring not "comparing apples with pears")

Porfolio balance (raw)
- technology maturity
- time to market
- targeting of particular programs
- risk
- sustaining, evolutionary, transformational spread
- tier
- product mix/offerings
- business lifecycle
- capability/knowledge

Summarised (post-workshop):

Commercial potential:
- Projected financial benefit
- Market growth
- Speed of payback
- Protectability

Strategic position:
- Partnership potential
- Capability development
- Competitive advantage / differentiation
- Credibility with customer

Risks and constraints:
- Commercial risk
- Technical risk
- Constraints (legal, environmental, political, partnership necessary …)

Cost:
- Cost (overall / to next review)
- Leveraged cost

Balance:
- Along pipeline (time, maturity, business life cycle)
- Over business (business area, product mix)

- Across capabilities/resource

Based on this project, four general categories of strategic option assessment criteria were identified that proved useful for clustering such criteria in subsequent workshops – these apply to individual options, and can be incorporated into portfolio matrix: two upside & two downside:.

- *Anticipated benefits* (positive factors), including:
  - *Commercial potential:* financially oriented measures, such as return on investment, payback, net present value, etc., which require a forward view of future revenues, based on market forecasts.
  - *Strategic position:* measures that are less amenable to financial analysis, which relate to establishing a platform for future revenues, such as competence building, branding, differentiation, etc.
- *Anticipated drawbacks* (negative factors), including:
  - *Risks and constraints:* commercial and technical challenges that will need to be overcome, together with issues such as legislation and standards.
  - *Costs:* investment that will be required to achieve the desired goal.

Aerospace #2 (2004)

Criteria	*'Sticker votes'*
Scale of risk & cost	10
ROI	8
Competitive position	8
Fit with wider UK strategy / policy	8
Value to customers / satisfies need	7
Risks quantifiable	7
Portfolio balance	7
Leads Astrium to winning & sustainable position	6
Clear & understood	5
Generates IPR or commercial advantage	5
Differentiate with respect to competition	4
Credibility	4
Opens up new business area	3
Supports company strategy	2
Teaming / partnerships	2
Attract external resources	2
Timing of investment / return	1
Serves multiple objectives	1
Not easily imitated	1
Makes money	-
Single very clear return or number of possible positive outcomes	-
Protectable	-
Breakthrough / significant step / novel	-
Spoken or *unspoken* customer need	-
Size / scale important for strategic options	-
Can we do it alone / do we need help?	-
Get competitors to work with us, not against	-

Packaging #1 (2003)

Positive:

Commercial potential (financials):	*Strategic position (non-financials):*
• Can we make more money?	• New market
• Can we sell it?	• IP – can we protect / exploit it?
• Synergies across business	• Cannibalise existing business

• Size of market	• Exclusivity • Ability to leverage longevity • Clear customer/consumer need (or create this)

Negative:

Cost and resources:	*Risks and constraints:*
• Can we make it? • Capital? • More labour • Development costs • Opportunity costs • Suppliers – what are getting into • Can we get a grant – external funding • Can it be made cheaper / faster? • Skills requirements	• Time to market • Competitive reaction • Impact on existing business • Commercial risk • Technical risks • Known technology • Capable of ongoing development • Environmental / legislation

Packaging #2 (2004)

Measure	*Votes*
1. Financial viability (ROI, payback, margin, EP)	14
2. Sustainable competitive advantage	13
3. Market need	10
4. Market growth potential	10
5. Patentability	10
6. Ease of manufacture	9
7. Capital required	9
8. Resources	9
9. Probability of success	9
10. Customer requested	8
11. Employee safety	8
12. Replace existing products	5
13. Lead time	4
14. Core competency	4
15. Entry / exit barriers	4
16. Competition	4
17. Technical capability	3
18. Longevity (sustainable)	3
19. Competing technology	3
20. Commercial risk	2
21. Environmental impact (regulatory)	2
22. Volume potential	2
23. Further opportunity with the same customer	1
24. Product liability	1
25. Material supply	1
26. Market share	1

Clustered (first-cut)

Commercial potential

1. Financial viability - ROI, payback, margin, economic profit	14
2. Market need	10
3. Market growth potential	10
4. Patentability	10

5.	Customer requested	8
6.	Replace existing products	5
7.	Competition	4
8.	Longevity (sustainable)	3
9.	Competing technology	3
10.	Commercial risk	2
11.	Volume potential	2
12.	Further opportunity with the same customer	1
13.	Market share	1

Strategic position

1.	Sustainable competitive advantage	13
2.	Ease of manufacture	9
3.	Lead time	4
4.	Core competency	4
5.	Technical capability	3

Risk & constraints

1.	Probability of success	9
2.	Employee safety	8
3.	Entry / exit barriers	4
4.	Environmental impact (regulatory)	2
5.	Product liability	1
6.	Material supply	1

Cost

1.	Capital required	9
2.	Resources	9