THE CSIRO PRIORITIES METHOD, 1990-1995

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1. INTRODUCTION

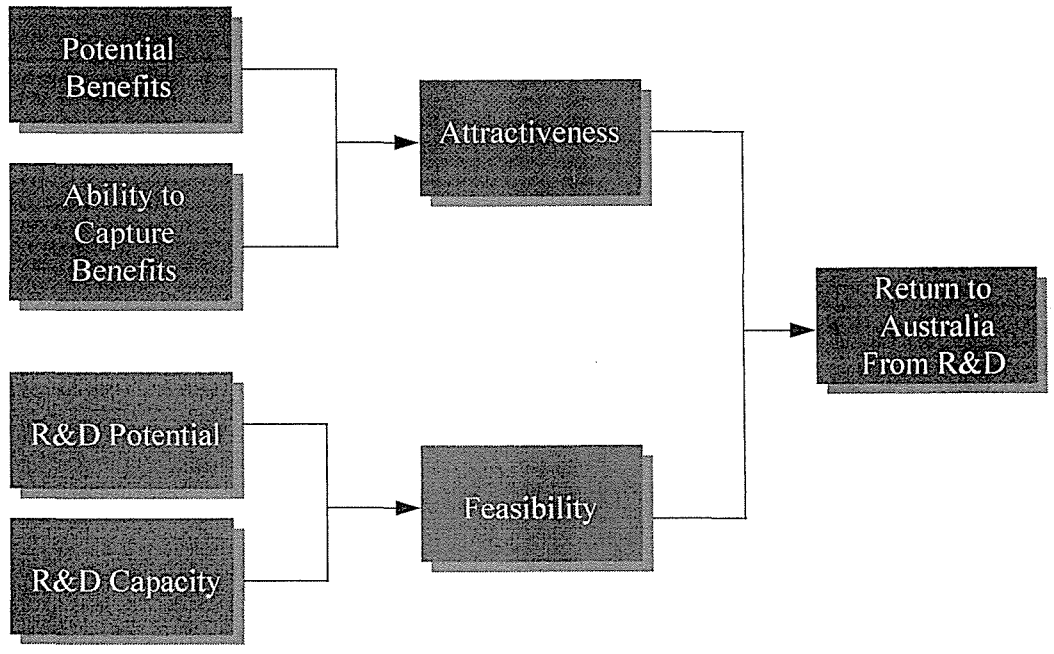
The CSIRO Priorities Method, developed in 1990, has been widely used in CSIRO and in a number of other research agencies in Australia and overseas. This paper looks at its origins, examines its scope and applications, and canvasses its future use.

The CSIRO Priorities Method

Although it has been modified for different applications the Method has three core elements:

- a priority framework, (Figure 1), for gathering and assessing information
- a scoring process using the four priority criteria
- a Feasibility-Attractiveness screen for display of results

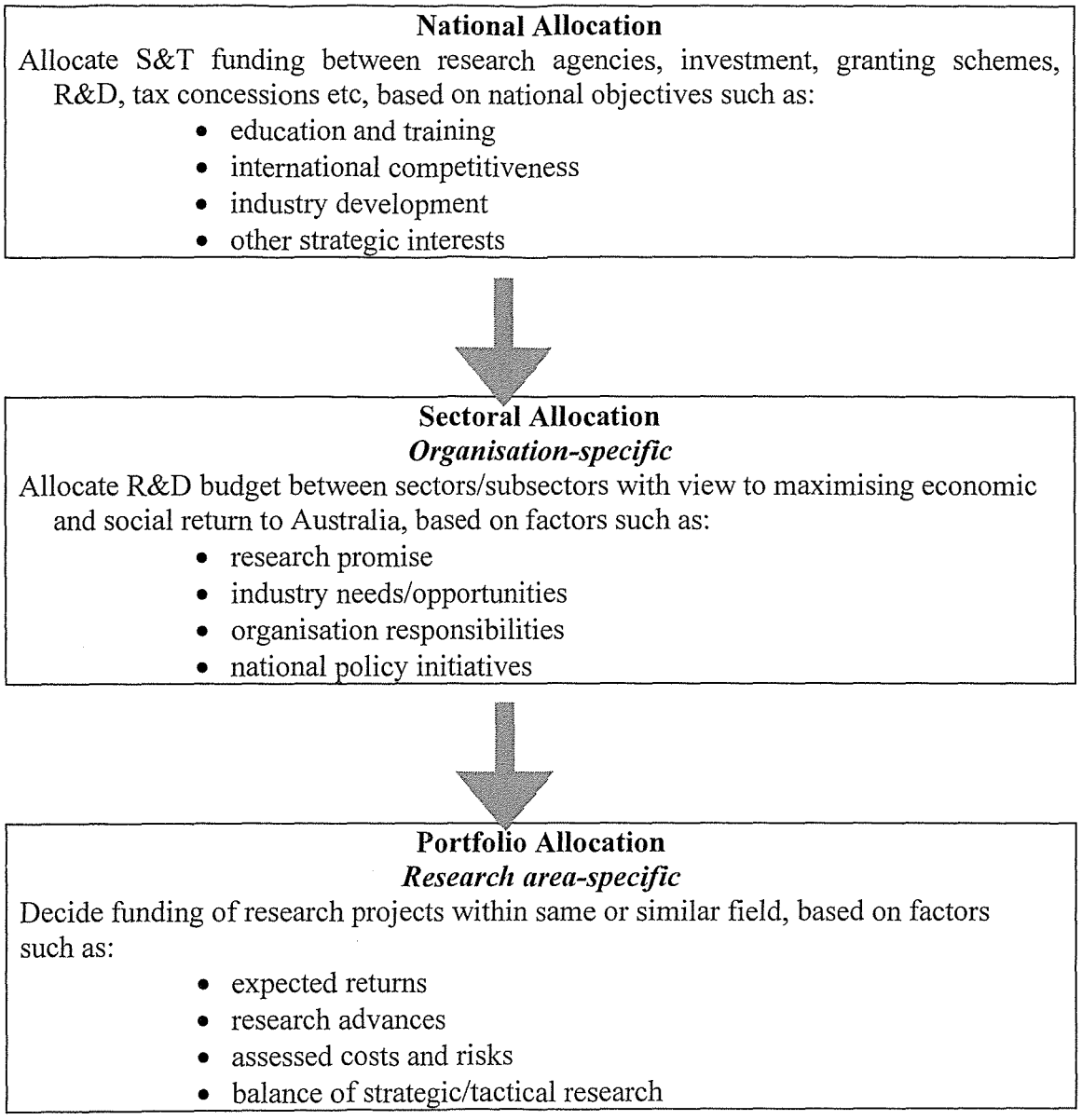
FIGURE 1: CSIRO PRIORITIES FRAMEWORK



Scope

The main use of the Method has been to assist the allocation of public sector research funding. Priority setting is a central and difficult challenge for all research, made difficult by the uncertain outcomes of scientific research. As Figure 2 shows the resource allocation process for public funding, moreover, arises at three levels, of which two, sectoral and portfolio allocation are amenable to the CSIRO priority method.

FIGURE 2: ALLOCATION OF PUBLIC R&D FUNDING



The first level, **national allocation,** involves distribution of public S&T funds across a wide range of purposes, eg between direct and indirect funding (such as tax concessions), and across an assortment of programs and academic and public research agencies. In Australia this process, which involves an array of overlapping and intersecting policy goals, is overseen by a complex Departmental and advisory structure feeding into the Government Cabinet decision making process. In the 1995/96 Budget a total of $3140M was allocated, of which some $1550M was provided for higher education research, $600M for science and innovation grants, $530M for IR&D and related incentives and $900M for research agencies (of which CSIRO received $417M).

The next level, **sectoral allocation,** involves funding decisions across a range of competing sectors. This process is generally overseen by a single organisation with a defined charter and operations. The unifying objective, for organisations such as CSIRO, is maximising the national (economic and welfare) return on public funding within its area of research activity.

The third level, **portfolio allocation**, involves decisions on program and project funding for maximum return. The task is complicated by the different risk, time and reward profiles of different research activities difficulties in comparing new and existing research activities. It is nonetheless a key responsibility of all research managers.

The use of the CSIRO Priorities Method in funding allocation is discussed below. Section 3 addresses sectoral allocation and Section 4 addresses portfolio allocation.

2 ORIGINS OF THE CSIRO PRIORITIES METHOD

The Framework

The central element of the CSIRO method is the Priority Framework.

This is essentially an accounting identity that separates measurable component elements. It finds its antecedents as long as 80 years ago in the development of a formula for combining cost and capital accounts by Donaldson Brown at Du Pont.1

In 1984 by the US Industrial Research Institute (IRI) Research on Research Sub-Committee developed a similar framework for identification of the key factors affecting the return on industrial R&D. (Foster et al., 1985) The IRI approach separated *R&D productivity*, an essentially technical management issue from *R&D yield*, which is directly related to market conditions and opportunities for exploitation if the technology is used.2 An important feature of this approach was the way it enabled technical and commercial information to be combined and compared. Information on scientific opportunities and research potential for a particular research activity was directly linked to information on the expected commercial value of the research and the likelihood of these benefits being realised in the market.

In a 1987 study for CSIRO the consultants McKinsey and Co adapted this method for the evaluation and ranking of research projects. (McKinsey, 1987) This approach was

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1 The formula stated that **R** (return on investment) equals **P** (ratio of net profit to sales) times **T** (ratio of sales to investment). This allowed separate reporting of sales and capital accounts and enabled **T** and **P** to be further disaggregated into component parts and separately reported.

Best reports the framework was applied successfully several years later as part of a reorganisation of General Motors, including the 'co-ordinated control of decentralised operations'. He notes "**P** was not new. Measuring earnings as a percentage of sales was as old as bookkeeping: it is the information that constitutes the income or profit and loss account of a business enterprise. Likewise, **T** was not new in that it uses the data found in the balance sheet. But defining turnover as the ratio of output to investment, breaking it down by department, and linking it to the cost accounts was new." (Best,1990)

2 The relationship was expressed mathematically as:

R&D Return *(profits/technical progress)* =
R&D productivity *(technical progress/ R&D investment)* x R&D yield *(profits/ technical progress)*

R&D productivity was further disaggregated into Potential Productivity, the maximum possible productivity improvement within the limits of the technology and Technology Development Efficiency, the efficiency of the R&D organization compared to the maximum possible. R&D yield was disaggregated to Potential Yield, the maximum economic return possible given the structure of the market and Operating Efficiency, the efficiency of "commercialisation effort."

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subsequently used in CSIRO studies of research linked to the polymer & plastics (Spurling et al., 1989) and biomaterials industries. (Upstill et al., 1990)

In 1990 the Framework was refined by CSIRO into its present form, allowing broad comparison of commercial and non-commercial research public sector research. The newly defined structure (Figure 1) disggregated the *Return to Australia* of research into *Attractiveness* and *Feasibility*. Each in turn was disaggregated to measures of scope - *Potential Value* and *R&D Potential* and efficiency - *Ability to Capture Benefits* and *R&D Capacity* - of different areas of research.

Table 1 summarises key stages in the evolution of the priority framework.

TABLE 1 EVOLUTION OFCSIRO PRIORITIES FRAMEWORK

	Purpose of development
IRI 1984	Analysis of key factors affecting return on R&D
McKinsey/CSIRO 1987	Evaluation and comparison of Research Projects
CSIRO 1990	Method to assist sectoral priority setting and R&D funding

Other elements of the Priorities Method

The two other elements developed by CSIRO in 1990 were, firstly, a process of scoring (or ranking) research alternatives against each of the four priority criteria and, secondly, a screen to display the outcomes.

The scoring process that was developed involved participants in way which was interactive, contestable and iterative. The final composite scores for *Attractiveness* and *Feasibility* were obtained from the average scores for each of the four criteria as follows:

$$Attractiveness = Potential\ Benefits \times Ability\ to\ Capture$$

$$Feasibility = R\&D\ Potential \times R\&D\ Capacity$$

The results could then be displayed on a *Feasibility* vs *Attractiveness* screen as a basis for decision making and resource decisions. (Elsum, 1990) The screen is shown in Figure 3. Also displayed in this Figure is the broad funding decision rule developed for use in CSIRO - namely the need for increasing selectivity for research in sectors closer to the Feasibility-Attractiveness origin.

Other display screens, namely *Potential Value* vs *Ability to Capture* and *R&D Potential* vs *R&D Capacity*, were also found to be useful in analysing key factors affecting the overall return on research.

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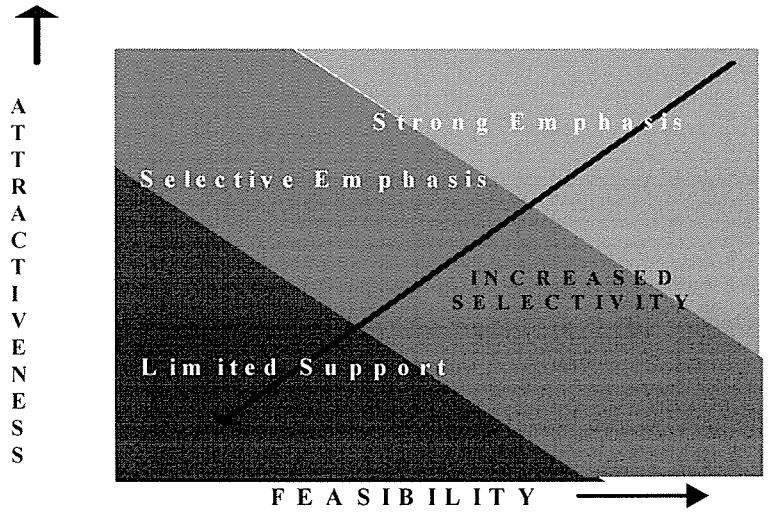
FIGURE 3: THE ATTRACTIVENESS - FEASIBILITY SCREEN



3. SECTORAL ALLOCATION

Use of the Priorities Method

The Priorities Method was developed by CSIRO for use in sectoral funding allocation and planning. It has also been used, directly or in modified form, for a similar purpose by a variety of other research funding agencies in Australia and overseas.

Notable among these are public sector R&D funding in New Zealand, in a process administered by the Foundation for Research Science and Technology, and priority-setting processes in the National Research Council, Canada. A feature of the recent United Kingdom Foresight exercise was the use of the CSIRO-based *Feasibility-Attractiveness* screen to display the outcomes of the national exercise. TIn addition the Method has also been used by research agencies in India and Turkey. Other non-CSIRO applications in Australia include its use in the strategic planning in rural research (Healy, 1992) by the Agricultural Departments of Victoria, New South Wales, Queensland and Tasmania as well as a number of other R&D agencies.

CSIRO Experience

CSIRO used the Priorities Method in 1990 and in 1993 in a major corporate priority-setting exercise to decide sectoral allocation for successive triennial budgets. This covered 14 sectors including Minerals, Information and Communications, Rural-based Manufacturing, and Environment Aspects of Economic Development, and involved a number of steps:

- assembly of data and information
- early involvement of workshop participants
- initial and iterative scoring and priority assessments
- determination of national priorities of relevant sectors

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- decisions on CSIRO response to priority outcomes (noting roles and activities of other agencies)
- sectoral funding decisions
- incorporation in strategic planning
- implementation of resource shifts.

Key elements of this corporate process - the key discriminant questions and the scoring procedures adopted as the corporate exercise - are shown in Tables 2 and 3. Outcomes of the two exercises and further operational detail are available elsewhere. (CSIRO, 1991,1994)

Since 1990 the process has also been used widely within CSIRO for further priority setting and resource allocation, for example between different subsectors of rural research.

TABLE 2 CSIRO PRIORITY CRITERIA: KEY QUESTIONS

POTENTIAL BENEFITS

- Who are the potential users and customers and how will they benefit?
- What parts of industry and/or the community will benefit from successful research?
- How will R&D contribute to industry growth and improved competitiveness?
- What is the size of potential markets in Australia and overseas, in value terms, and what are their growth prospects over the medium to long term?
- Are there any other important benefits, direct and indirect-environmental (degradation avoided), social (social amenity, health, safety), employment creation?
- Are there spillover benefits to other industries?

R&D POTENTIAL

- How close are the physical and technical limits in the relevant R&D?
- Are fields mature or developing? (Where is current technology on the S-curve?) - ie., is the rate of change rapid, moderate or slow?
- What are the prospects for developing commercially valuable intellectual property, scientific breakthroughs, or major improvements in mature technologies and fields?

ABILITY TO CAPTURE BENEFITS

- How will successful research be captured in Australia; what is Australia's ability to exploit the results?
- Are there potential commercial partners?
- Can the benefits from the research output be protected?
- What are the incentives/imperatives for adoption by commercial or public sectors?
- What is the industry's and/or community's commitment to R&D and technical innovation?
- Can Australian users compete internationally?
- Are there factors and conditions likely to promote or impede uptake, such as regulations, industry structure, physical conditions, ethical, cultural/social, environ-mental or political factors?

R&D CAPACITY

- Would the proposed research effort (in terms of the quantity and quality of resources - critical mass and quality of researchers) be internationally/nationally competitive in the research field?
- What is the competitive advantage(s) of Australia's (CSIRO's) research effort?
- Who are the major international (national) research competitors?
- Does Australia/CSIRO have the capacity to deliver the research, in terms of adequate skills, facilities, and time frame for effective application?

Value of the Approach

The Priorities Method has proven valuable for CSIRO in a number of respects. It has been central to CSIRO's corporate priorities process and to the implementation of related resource shifts in its triennial budget. It has achieved a high profile within CSIRO with the strong

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backing and commitment of the Chief Executive, executive management group and the Board. (Stocker, 1990). The Method has also allowed the social and economic factors to be considered alongside technical factors such as scientific potential and excellence in assessing the claims of research for different sectors. (This has been an important contribution during a period when the Organisation has moved to become more "end-user oriented").It has, moreover, provided a "common language" for multidisciplinary discourse on research priorities, and as means of promoting convergent views.

TABLE 3 CSIRO PRIORITIES METHOD : TYPICAL SCORING PROCESS

Prior to the Workshop

- All research purposes are scored prior to the workshop and scores recorded on summary score sheet.
- Key discriminate questions are used as guide when making assessments based on Data and Evaluation Sheets and other relevant input material provided.
- Each research purpose is assessed in order and each criterion separately. For each criterion a score of between 1 and 10 is assigned.
- The scores are reviewed, using the summary score sheet as a guide. Need check for consistency within each criterion, scoring research purposes judged highest and lowest as 10 or thereabouts, and 1 or thereabouts, respectively
- The pre-workshop scores are collected from participants entered into a spreadsheet to generate the preliminary attractiveness-feasibility plot.

During the Workshop

- Taking each criterion in turn, expert for each research purpose gives an overview.
- Pre-workshop scores are surveyed to locate outliers within the group - those whose scores deviate most from the group mean.
- Following discussion and debate participants may rescore if they assess it to be necessary.
- Participants complete score checks, the revised scores are entered into a spreadsheet and the revised screens are produced (Attractiveness, Feasibility, R&D Return).
- The group reviews the screens to check that the relative positions properly depict the outcome of the discussions.

On the other hand it has been criticised for the modest impact it appears to have had on overall CSIRO funding patterns (Industry Commission, 1995) and there have been calls for wider participation by industry and government stakeholders. From within CSIRO, criticism has focused on the way resource shifts have been implemented, rather than on the Priority Method itself.. With this reservation,the Method has achieved a relatively high level of acceptance.

A recent analysis, based on work by Mintzberg (1994), shows the process faring well overall. Mintzberg's view is that the factors most conducive to successful planning within an organisation are **commitment** to the process and its outcomes, and the **congeniality** of the internal climate to planning processes and change. Table 4 summarises a development of this approach, based on disaggregation of these factors into constituent **ownership, simplicity, convergence and utility** elements. (Blyth & Upstill 1994) Analysis shows CSIRO's process has performed satisfactorily against these evaluation criteria.There are, nonetheless ways in which its effectiveness could be strengthened, and these are addressed below.

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TABLE 4 SUCCESS FACTORS IN PLANNING PROCESS

COMMITMENT	**simplicity**	The process should be: • robust and easily understood • adaptable Highly complex processes suffer from lack of understanding by those who should be involved.
	ownership	It should be: • driven by the Chief Executive capable of engendering ownership of results and outcomes by all involved
	.....	
CONGENIALITY	**convergence**	It should be: • encompassing and inclusive • involve different disciplines The process should be a meeting ground and a market place for ideas.
	utility	It should allow the Organisation: • to address pressing issues • to present the results to stakeholders and other audiences

4. PORTFOLIO ALLOCATION

Priority setting and project funding

The task of evaluating and prioritising projects within a research portfolio is complex and requires a range of techniques. Moreover, techniques need to be adjusted according to the "life cycle" of the project. Research portfolios typically include a range of projects of different size and maturity. And evaluation/ selection processes need to change when moving from exploratory investigations to highly focused and application-oriented activities (Steele 1988).

Figure 4 illustrates this point, namely that relatively informal selection processes may be appropriate for projects at an "exploratory" stage where projects are generally large in number, small in size and involving a high degree of uncertainty. More formal processes, even rudimentary business planning are appropriate for mature projects which are generally fewer in number and much larger in size.

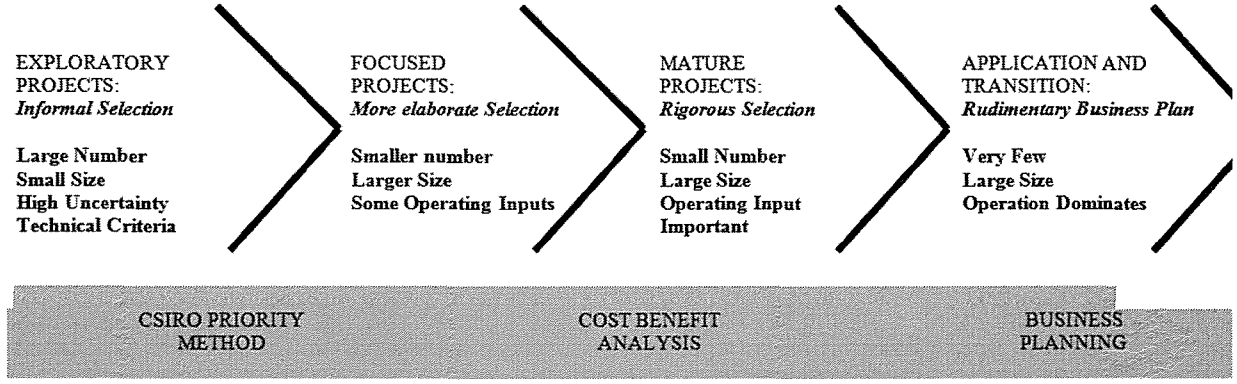
CSIRO Experience

The Priorities Method has found use in CSIRO as a portfolio management tool. For example:

- in the screening and ranking of early-stage projects. The four priority criteria serve as a useful way of marshalling available information and addressing potential constraints. While not a rigorous decision tool the Method provides a useful common basis for discussion.

- in several cases, for evaluation of competing research proposals, eg in the waste management area (CSIRO 1993). Information on each project is compiled and presented according to the four priority criteria,[3] followed by scoring and plotting results on the *Attractiveness-Feasibility* screen as a basis for funding decisions.
- for project reporting. Each of the research projects in CSIRO Industrial Technologies has since 1992 maintained a project data sheet, following the pro-forma layout shown in Table 5 and based on the four priority criteria. These are updated regularly and provide an effective basis for comparing and monitoring projects operating across a wide range of research activities

FIGURE 4 PROCESSES NEED TO MATCH PROJECT SIZE AND MATURITY



Value of the Approach

The CSIRO Priorities Method deserves recognition as a technique that can be used in project ranking and in the allocation of funding for multi-project research programs. As shown in Figure 4 it is a complement rather than an alternative to detailed cost-benefit evaluation and business planning.

While early stage projects may be addressed by detailed cost-benefit analysis, the technique is difficult and expensive to employ with rigour. The CSIRO Method can more easily incorporate qualitative and semi-quantitative information whereas a cost-benefit approach is more directed toward generation of a single numerical answer and better suited to the assessment of well-defined projects.

These observations are consistent with the findings of a recent Bureau of Industry Economics study of CSIRO industrial researchin which the similar theoretical underpinnings of the two

[3] This is similar to the approach developed in the 1987 McKinsey/CSIRO study for evaluation and comparison of research projects.

TABLE 5 GUIDELINES FOR ONE-PAGE PROJECT DATA SHEETS (CSIRO INSTITUTE OF INDUSTRIAL TECHNOLOGIES, 1994)

DESCRIPTION

Background: Brief account of the nature and purpose of the research, indicating current and planned activities.

Objectives: The scientific, technical and commercial objectives of project presented in a way that provides a basis for explaining potential benefits.

MILESTONES

Major research and commercial objectives and commitments (not continuing phases of a project).

Limited to discrete measurable events which unambiguously have or have not happened by the due date- generally 2 or 3. Target dates will be the nearest quarter in most cases.

Date and brief details of review process (most recent, next major review).

COMMERCIAL BENEFIT (POTENTIAL BENEFIT)

What industry will benefit from the successful completion of the project? How?

What is the size of the potential market in Australia and overseas?

Are there any additional benefits? e.g. other economic, environmental or social benefits.

COMMERCIAL CAPTURE (ABILITY TO CAPTURE BENEFITS FOR AUSTRALIA)

What is current IP and patent position and strategy? How does this fit with major international competitors in this field?

How will successful research be captured in Australia?

Which companies are current commercial partners?

Which are potential commercial partners?

Would benefit to Australia by way of licence fees or royalties make an off-shore partner attractive?

R&D POTENTIAL

A technical appraisal of the likely scientific return on research efforts in this field.

What are prospects for success? What new developments are possible or likely?

Section should address maturity/predictability of this research field worldwide.

Is it rapidly changing? Will rewards come in form of major breakthroughs or improvements in mature technologies?

How far are current applications from physical limits? ("S" curve analysis may contribute).

RESEARCH COMPETITIVENESS (R&D CAPACITY)

Is current research, including research collaboration arrangements, of critical size and internationally competitive. If not, what is being done about it?

What is competitive edge for research in this field?

What is current (and anticipated) intellectual property position?

Where does research in project rank internationally? Who are major research competitors?

RESOURCES

To cover past year, current year, and next three financial years

Project Cost (including overheads); Total Staffing; External income [Assured plus Projected (>80% probability)].

RESEARCH CLASSIFICATION

Socioeconomic Objective Classification; name of code, percentage of research attributed to this code.

UPDATE Month and year of update.

approaches were noted. In both cases demand-side expertise needs to be combined with the supply-side expertise in order to address the value and the costs of envisaged technological advances.

> Cost information involves expertise in R&D supply, and is typically the province of R&D managers, who have specific technical expertise in both the expected resource needs of various technological goals and the degree of uncertainty and risk associated with them. Revenue information is associated with the demand for R&D outcomes, and is typically the province of specialists in the relevant markets.(BIE, 1992, p.32)

5. FUTURE APPLICATIONS

The level of acceptance and use of the CSIRO Priorities Method over the past five years suggests it has value in addressing the challenging task of allocating public sector research funding, especially at a time when research agencies are promoting efforts to focus on the value of research to the end-user rather than to scientific merit alone. This requires a combination of perspectives in the assessment of the expected value of research - a technical assessment of what might be delivered and an economic or social assessment of how these outcomes would affect the world. What is needed is a dialogue between the two perspectives.

Moreover, the assessment process frequently needs to look beyond private economic return and to other factors such as spillover benefits to other firms or industries, improvements in environment management, and contribution to national objectives.

Since 1990 the CSIRO Priorities Method has demonstrated merit in assisting this process and R&D funding allocation. It offers a consistent basis for assembling and analysing relevant information, and a common language for dialogue between technical and commercial experts, and finally an interactive forum for decision makers to consider a wide range of research activities. It has proved to be robust, simple and adaptable. Nonetheless it will need to continue to evolve if it is to continue to be just as useful in the future.

In relation to sectoral allocation some key challenges for CSIRO are:

- the systematic involvement of government and industry stakeholders in the corporate process to ensure outcomes are representative of broad national needs. This is an issue addressed in the recent Industry Commission and CSIRO Board Evaluation reports. (Industry Commission, 1995; CSIRO, 1995)
- further "evolution" of the key criteria, eg an increased emphasis on international competitiveness in both *R&D Capacity* and *Ability to Capture*. This requires looking beyond the local and Australian arena cases and an informed awareness of international standing and prospects. These are critical if research is to exercise maximum leverage to assist Australia's export industries.
- incorporation of external advice to supplement CSIRO expertise in relation to the potential of new and emerging research and technology areas.
- streamlined use of scenario planning and other techniques to assist priority setting (avoiding the the problems of "information overload").
- maintaining the transparency of the process and the widespread commitment to its success. In particular this requires careful planning of implementation phase and implementation of funding changes.

In relation to portfolio allocation there is clear scope for wider use of the CSIRO Priorities Method as a tool for early stage evaluation and screening. In particular the employment of the priority framework as the basis for project reporting (Table 5) and monitoring warrants consideration for wider adoption.

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