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# Remaking National Science Policy and Public Sector Research for the 21st Century

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*The Economists, not only in the west but also in the east, are essentially materialistic. We must say harshly of the "science" of economics that it is generally the skilled, exact, technological application of a totally false theory of human needs and values. A theory which recognises only the existence of lower needs or material needs. How could young people not be disappointed and disillusioned! What else could be the result of getting all the material and animal gratifications and then not being happy as they were led to expect, not only by the theorists, but also by the conventional wisdom of parents and teachers, and the insistent grey lies of advisors (Maslow, 1967).*

# THE NEED FOR A NEW PARADIGM IN SCIENCE POLICY

## The Pressure for Change

For the past twenty years, there has been a fairly constant 'fiddling with the research system', driven by a view that not all is right, and that some improvement of its operation must be possible, even if a clear model of reform is not apparent. Thus, we have seen repeated attempts to restructure CSIRO in order to address one or other national issue. Indeed, restructuring CSIRO has achieved the status of a peculiar national past-time, carrying with it a powerful image of political frustration and failure.

The continuing nagging dissatisfaction on the part of politicians and officials, and consequent attempts to restructure or review the 'science system' to get it to work better, has led to regular calls, particularly from the scientists, for the formulation of a '**national science and technology policy**' to sort out these problems and let them get on with their work.

*'To me, the entire issue of the future directions of scientific research in general, and CSIRO in particular come back to the question of setting of priorities which reflect the needs of the customer* (for applied research) *and stakeholder* (for public good research) *and enables the provider* (the scientist) *to meet their requirements in the short, medium and long term' — CSIRO commentator.*

Such a centralised approach to the establishment of national objectives has, however, been something politicians have neither seen a need for, nor known how to construct. The rhetoric, and reality, of a pluralist science and technology system has been called on regularly to argue that there was little need for top-down consideration, or centralised leadership.

But now there are emerging signs that marginal structural adjustments to our research system are not only proving ineffective, but are to a large extent counter-productive. These structural modifications also signally fail to address the dramatically changed role of knowledge in shaping our economic, environmental and social future.

The conjunction of three significant and largely distinct influences suggest that now is the time for major reconsideration. The first of these is the growing, one might venture widespread, recognition of the dominant contribution of knowledge to economic competitiveness in this age of globalism.

> *'Knowledge in the form of technology and market information, is the principal resource in the world economy, especially knowledge in its dynamic form as the capacity to generate new technologies and to market new products' (Cox, 1987).*

The emphasis of our current, but no longer appropriate science policy paradigm, has been almost exclusively on the generation of knowledge. The challenge now is to develop a model which can underpin understanding, and policy, across the full and much richer spectrum of knowledge activity.

The second force for change arises from advances, predominantly in the past ten years, in the theories, concepts and language to analyse and understand the basis of this economic activity, the centrality of innovation, and the characteristics of the knowledge system under these conditions.

The third force is more local, and relates to a number of government activities in Australia: firstly, the release of the Industry Commission draft report on Research and Development (1995); secondly the commitment of the Minister for Industry, Science and Technology, Senator Cook, to release an 'Innovation Statement' in August 1995; and thirdly, the continuing, public and divisive debate about the appropriate role, structure and management of CSIRO.

## The Current Paradigm in Science and Technology Policy

The current paradigm in science and technology policy is composed essentially of two distinct elements: the economists' view of scientific knowledge as a public good, and the scientists' view of research as an endless source of knowledge upon which new activity can be built.

These two views are not necessarily coherent, though as we shall see they have provided implicit support for each other. It could even be argued that, on some issues, they are in conflict. The reality, however, is that together they have provided the rationale and supporting rhetoric which underpins modern (post-1945) science policy.

It is necessary to examine these arguments in a little detail in order to establish the extent to which they have provided, until recently, the largely unchallenged basis of science and technology policy. In this Chapter, we must grapple briefly with the arcane language of economics in order to expose its limitations in addressing the world of research and knowledge.

In doing so, it will be apparent that the neo-classical economic argument is conducted almost exclusively in terms of the direct economic returns from the research process. It does not take any explicit account of the role of knowledge in pursuing environmental, social, or cultural objectives.

The economist's view of science is firmly established in the academic literature, policy analysis, and public discussion. Indeed:

> Generations of students have learned that science is a public good. This principle has been embraced by economists of all shades. It has inspired science policymakers; it is supported by scientists themselves and even seems to fit in with the common-sense view (Callon, 1994:397).

Scientific knowledge is regarded as having a range of intrinsic characteristics that make it impossible for it to be treated, or managed as just another commodity; as a consequence there is an imperfect market for this knowledge, which causes business to under-invest; this market failure provides a justification, indeed a powerful reason, for governments to act to supplement and stimulate this investment.

The list of these 'intrinsic characteristics' varies, but is generally considered to include:

- **limited appropriability** — this claim rests on the view that it is impossible to create a market for knowledge once it is produced, because others can access the knowledge at little or no cost, so producers have a limited ability to appropriate the benefits of their investment;
- **non-rivalry** — knowledge is a non-rival good, in that once produced, its use by one person does not preclude its availability and use to others; an important consequence is that 'the good's production costs are fixed: once the good has been produced, there is no need for continuing investment because there are no production costs in replicating it' (Callon, 1994:400.);
- **uncertainty** or **risk** — knowledge outputs are not precisely predictable; it is necessary to invest in knowledge production without knowing the outcome with any accuracy;
- some commentators have added the quality of **durability**: the knowledge good is not destroyed or altered by its use; indeed increased use of a piece of knowledge can increases its value and applicability;
- a final characteristic commonly referred to is **indivisibility** — knowledge must be aggregated on a certain minimum scale to form a coherent picture before it can be applied.

Together, these characteristics provide the basis for scientific knowledge being treated, and supported, as a public good, the production of which is subject to market failure.

This market failure analysis has been widely accepted as providing a sound justification for government intervention to support research with public funds:

> In this set-up, the basic policy task is to encourage discovery-oriented activities, and then to protect the use of the results. The problems of risk and indivisibility lead to straightforward under-provision of knowledge, and suggest that the public sector should either produce knowledge directly, or provide subsidies to knowledge-producing institutions. The appropriability problem implies the existence of a major positive externality, and suggests policies either of subsidy, or the creation of property rights (OECD, 1994a:8).

However, as some commentators have noted, this approach

> does not give any secure guide to how to identify areas of market failure, or the appropriate levels of public support which might follow from it. There appears to be a rationale for public provision, but where and how much? (Metcalfe, 1994).

Indeed, it can be argued that market failure theory has been used primarily as a device to legitimate politically inspired policy (Joseph and Johnston, 1985). But demonstration of these limitations has done little to dent the command of the official paradigm.

Complementing this economic component of the current paradigm in science and technology policy are the political views which the scientific community managed to establish in the 1950s as the basis of the social contract between science, the community and government.

The exemplary author of the post-War contract between science, governments and the community was America's Vannevar Bush (1947), in what is one of the most famous and oft-quoted government reports, 'Science, the Endless Frontier'. His arguments rested on two assertions.

The first of these was:

- basic research is performed without thought of practical ends.

In Bush's view creativity is constrained by any thought of application, which implies that there is:

> an inherent tension between the goals of understanding and use and, by extension, a radical separation between the derived categories of basic and applied research (Stokes, 1994:2).

Stokes goes further to argue that Bush implied that applied research inevitably drove out basic research if the two ever came into contact. Here is a clue to the origins of the linear model of innovation which has so dominated Western industrial society for the past fifty years.

The second claim, which at the time must have seemed somewhat paradoxical, provided the delivery end of the social contract between science and government:

- basic research is the pacemaker of technological development.

> If basic science is not short-circuited by premature thought of practical use, it will prove to be a remote but powerful dynamo of the technological advances that will meet the full range of our society's needs, as the advances of basic science are converted into technological innovations by the processes of technology transfer (Stokes, 1994:2).

The power of these ideas has been quite remarkable. They spawned not only the modern form and extraordinary growth of science, setting its path irreconcilably from intellectual pursuit to industrialised manufacture. But they also very significantly contributed to the shaping of the modern industrial, and indeed, post-industrial, society. Their roots have penetrated so deeply that the majority of scientists, and many of the public, consider them to be a statement of the natural order, eternal, and unquestionable.

Yet it always was a dangerous bargain. In return for the unfettered funding of basic research, the commitment was implicitly made that all of society's needs, whether wealth, employment, health, security, or the good life, would be satisfied. But not only have 'old' problems such as starvation and conflict not been resolved; 'new' problems such as ecological sustainability have been added to the list. It was inevitable that a demand would emerge for a new 'social contract' between science and government.

It should be noted that this public good/market failure view of scientific knowledge was implicitly based upon, and has provided strong conceptual and rhetorical support for, the linear model of innovation. The central tenets of the linear model have been that technological advance and advantage depend on knowledge creation at the frontier; that science provides the prime knowledge base for industrial production; and that the translation of knowledge into commercial products is essentially sequential.

The most powerful implication of the linear model is the view that industrial innovation is primarily driven by the discovery processes within science. As a consequence, public policy has emphasised government support for R&D, subsequent commercialisation, and technology transfer.

There have been many demonstrations of the conceptual and empirical inadequacies, indeed distortions, of the linear model (Gibbons and Johnston, 1974; Pavitt, 1991). However, these apparently well-argued cases have had relatively limited impact on the fundamental basis and practice of science policy. The linear model has resonated too strongly with deeply held views, and the nexus between the economists' public good and the scientists' view of the primacy of their knowledge has been too strong, to allow simple factual inadequacies to count for much.

It has become apparent that the overthrow of the linear model will require a much deeper, and concerted challenge to the set of ideas which constitute the dominant 'world view' of science and technology policy.

## Reassessing the Basis of the Current Paradigm in Science and Technology Policy

There are at least three major challenges to the current paradigm, and the views of research and industrial innovation upon which they are based.

The **first** of these is concerned with the supposed **non-rivalry**, and **appropriability** of scientific knowledge. The common emphasis is on the limited extent of control of new knowledge by the research performer. However, the fact that the producer of knowledge may have limited control over who can get access to it, (for example, anyone who can read the scientific literature) does not necessarily imply that such knowledge is freely available.

This argument can be countered from two perspectives. One is that the sociology of scientific knowledge has demonstrated that an isolated 'piece of knowledge', statement, or theory, is quite literally useless, indeed has no meaning, unless it is embedded in a supporting context of well developed theory, evidence, and argument.

> You might print thousands of copies of an article or a book and air-drop copies in Lapland or in Bosnia-Herzegovina. You might similarly send well-trained students or well-calibrated instruments to the far corners of the earth. However if all these elements do not come together in a single place at the same time, then dissemination will have been a waste of time. Nobody will

> adopt the statement; the skills will not have any object to which they can be applied; the instruments and the machines will remain in their boxes (Callon, 1994:402).

Making use of any piece of knowledge requires a considerable investment in establishing the necessary interpretive context of theory, concepts, data and tacit experience.

The other is that a scientific or technical resource has no intrinsic value or use. It is only when the necessary 'complementary assets' (Teece, 1988) of technological support systems, production capacities, and distribution networks are appropriately assembled that knowledge can be converted to profitable use: 'A veritable collective machinery is required to give knowledge a use or economic value' (Callon, 1994:409).

Thus, a public good is not necessarily a free good (Pavitt, 1991:117). The extent of the public or private nature of scientific knowledge is highly variable, and context-dependent, rather than an intrinsic property of the knowledge itself: 'Degrees of appropriability and of rivalry are the outcome of the strategic configurations of the relevant actors, of the investments that they have already made or are thinking of making' (Callon, 1994:407).

The **second** major challenge comes from the phenomenon variously referred to as **irreversibility, increasing returns**, or **path dependency** (Arthur, 1989; David, 1984). In order to limit the potentially infinite number of goods that could be offered on the market place, to allow the consumer the possibility of 'ordered, informed choice', and to ensure the possibility of a return on the investment in new technology and new products, what Callon aptly calls 'that strange conspiracy between technology and the marketplace' (Callon, 1994:408) occurs to develop a common techno-economic trajectory. Furthermore, it is the initial decisions concerning technology and design that commonly provide the powerful and self-reinforcing determinants of that trajectory.

*The 'QWERTY' keyboard is the most familiar example of a technology that was shaped by a particular problem (the need to avoid mechanical keys sticking), which could be displaced by a far more efficient layout, but which is locked in by the variety of dependent and associated products and uses.*

Under these conditions, the emergent trajectory acts as an active shaper of not only the value of knowledge items, but of the extent to which they have any meaning. The overall process can be presented as the generation of knowledge which 'fits' within the system, and a large range of other knowledge candidates which do not fit, at least at that time, are left to pile up in storage, some to be used at a later date, and many never to see the light of day again.

Under these conditions, what is commonly called public good science, might be seen as a source of variety in knowledge, outside the confines of the accepted trajectories. It provides the mutations which are assessed via the selection criteria of the existing evolutionary systems, and which occasionally challenge successfully, and transform, the dominant paradigm, leading to the formation of completely new bodies of knowledge, new technologies, and new industries.

The **third** major challenge is presented by advances in the theoretical and practical understanding of **the innovation process.** The past decade has seen major changes in the understanding of the nature and characteristics of innovation processes, and their economic effects, through the application of 'systems' approaches (Nelson, 1987; Dosi et al, 1988; Scott-Kemmis and Johnston, 1988; Freeman and Soete, 1990; Dodgson and Rothwell, 1994).

Analyses of industrial clusters, as in the work of Michael Porter (1990), emphasise the creation of dynamic clusters of industries around key technologies, emphasising inter-industry interactions and the effects of the politico-economic environment.

An alternative approach is based on 'national systems of innovation', composed of 'elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge' (Lundvall, 1992; Nelson, 1993). This relies on analysis of innovative environments, processes of learning, and knowledge accumulation.

Yet another approach rests on the concept of the 'knowledge system' and focuses on learning systems for scientific and technological knowledge. David and Foray have developed the concept of:

> "knowledge-product space", which is essentially a way of categorising different forms of knowledge by placing them with respect to three different dimensions: from completely tacit to fully codifiable, from fully disclosed to fully restricted; from privately owned to publicly available (OECD, 1994b:13).

This differentiation of knowledge types provides a basis for analysing the characteristics of 'effective' knowledge, and the conditions for its effective application which is very different from the perspective offered by neo-classical economics:

> within this complex structure of differentiated knowledges, what determines performance is not so much knowledge creation as the "distribution power" of the system: the system's capability to ensure timely access by innovators to the relevant stocks of knowledge. The distribution power of the system affects risks in knowledge creation and use, speed of access to knowledge, the amount of socially wasteful duplication, and so on (OECD, 1994a:13).

The common threads running through these 'system' approaches, with their emphasis on evolutionary systems of innovation, organisational learning, and a range of non-market transactions such as cooperation and collaboration, are a rejection of the assumptions underpinning the neo-classical model of economic activity. Instead, they emphasise interaction:

> the overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities, etc) perform, but on how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as values, norms, and legal frameworks) (OECD, 1994b: 4).

These new analyses of innovation suggest a very different status of knowledge to that presented by the neo-classical model. Technological knowledge systems within industrial firms are characterised as :

- differentiated and multi-layered, ... involving the complementary development of very different types of knowledges: codified scientific results, tacit knowledges ...;
- highly specific, organised around a relatively limited set of functions which firms understand well;
- developed through costly processes of search, learning and adaptation, and are therefore cumulative;
- internally systemic, as part of an overall production and marketing system, including identifying and integrating technological and market opportunities, financing new product and process development, training, design, engineering and prototype developments; and
- interactive and externally systemic, based on structured interactions between institutions, involving processes of mutual learning and knowledge exchange (OECD, 1994a:11).

Hence, firms in general are severely constrained in their knowledge horizons and technological capacities. As a consequence, they are likely to have great difficulty in identifying and accessing scientific or technological information from outside their restricted environment. They also rarely have costless access to a generic knowledge basis, and therefore are required to invest in the location and 'purchase' of highly specific knowledge to achieve their innovative goals. A great deal of knowledge is not available as a commodity for purchase, and must be obtained through investing in the establishment of non-market relationships.

This provides a much broader justification for government support for public sector knowledge organisations than that of spillovers from public good research afforded by the neo-classical view. Such organisations are not simply engaged in the uncertain practice of research in support of national objectives. Rather, they provide the central core of the knowledge infrastructure of the nation, assembling and disseminating relevant knowledge throughout the economy and social structure. Parts of this infrastructure exist within, and can be provided by, the private sector. But the non-market nature of many of the transactions indicates the importance of a continuing role for public sector involvement.

This raises, however, a significant challenge for public sector research organisations like CSIRO. By objective, by ethos, and by recruitment, their emphasis has been on the performance of quality research — a very demanding requirement in itself. However in practice, in some Divisions there has been a considerable effort in the assembly, interpretation and communication of relevant knowledge to identified groups of potential users, precisely through the formation of long-term, non-market relationships. Under a new policy model, it would be necessary for a CSIRO to reconstitute itself as a knowledge management organisation, rather than just as a research organisation.

## Some Components of the New Framework for Science and Technology Policy

The evolutionary/systems view of innovation and the roles of technological knowledge outlined above provide the basis for a quite different view of the appropriate form of government intervention in the world of research and knowledge transfer. Whereas current neo-classical-based policies place all their emphasis on support for knowledge creation, the evolutionary model points to coordination across all components of the knowledge system. The most appropriate place for public support may be in providing mechanisms to assist in knowledge identification, location, and distribution, as well as knowledge generation.

As a consequence, it is:

> knowledge of how to develop new knowledge, how to locate and acquire rapidly knowledge generated elsewhere, how to diffuse knowledge throughout an organisation, how to recognise possible inter-connections between two distinct pieces of knowledge, how to embody knowledge in products and services, how to obtain access to the learning experiences of customers — all of these are the challenge for the modern manager, and for those who would make science policy (OECD, 1994a:14).

In summary, the new paradigm for science and technology policy will:

- focus on interaction as much as on institutional performance;
- characterise knowledge and its value in accord with the categories of knowledge-product space, rather than in terms of the traditional distinction between basic and applied research;
- emphasise knowledge distribution and access as a coherent continuum with knowledge generation;
- take full account of the non-traded nature of knowledge interaction;
- comprehend the tacit nature of much knowledge, and its important role in framing questions and possibilities as much as in solving problems;
- acknowledge the necessarily limited technology horizons of industrial firms, and the need for knowledge workers (the researchers in this new model) to find ways to interface with those horizons.

## KEY ELEMENTS OF A NATIONAL SCIENCE POLICY FOR THE 21ST CENTURY

One way of examining the requirements of a national science policy is in terms of the key elements to be delivered by it. These can be considered as: the generation of new knowledge; access to the world's knowledge base; capturing the benefits of knowledge; and the provision of informed input into decision-making at all levels and sectors.

The **generation of new knowledge** is a continuing requirement of a research system, to address new problems, to open up new opportunities, to conduct the new generation of researchers to the forefronts of knowledge, to maintain and develop new contacts with the international research community, and to have the basis of accessing and interpreting knowledge generated elsewhere.

There are a number of crucial elements of a national capability to generate new knowledge. The first of these might be the provision of an appropriately trained and experienced labour force of researchers. This issue provides a good illustration of the complexities and interactivities of the research system.

Initially, talented students must be attracted to study science and mathematics subjects at school. This requires, as a minimum, well-trained and enthusiastic students, a challenging curriculum, adequate infrastructure, equipment and materials to support both the directed and discovery learning processes, a widespread perception of the social and financial value of a career in science, and a school and community culture that values education and achievement.

Then there is the requirement for universities with adequate resources, a commitment to excellence in undergraduate and postgraduate learning, a strong research ethos, adequate facilities, well-developed connections into the international scientific community, and an ability to communicate the challenge and excitement of the research process, and the extreme self-discipline required to be successful.

There is a further need for a strong labour market for researchers, with provision for an attractive career, the possibility of moving freely between a range of employers, financial and social status, a significant level of autonomy and responsibility associated with a professional, and the opportunity to work towards challenging objectives.

A second requirement is infrastructure to support the generation of knowledge. This includes not only laboratories, equipment, information resources, funds to attend meetings and conferences, etc, but the organisations to provide the necessary general support structures. A significant level of generation of new knowledge will occur in the private sector, or be supported by it. But the analysis presented previously also indicates the need for a continuing and substantial public investment in knowledge generation.

While the obvious infrastructure is material, the research process also relies intensely on more intangible infrastructure: for example, the ability to test new ideas with trusted colleagues, to exchange the results of experiments, and experimental material, to 'pick up' on the tacit elements of a new experimental procedure, to access results long before formal publication. Access to this infrastructure is available only to those who have established themselves as accredited and reliable researchers, and who have demonstrated their commitment to the sharing ethos of science. Hence there is a continuing requirement for a system of apprenticeships to transmit to new practitioners the technical, social and ethical requirements of their profession.

A third component of the research infrastructure is the ethos, and culture, which supports the highly uncertain nature of the research process, that allows failure, as long as it leads to learning, and which recognises the necessarily long time horizon of research. After all, with an apprenticeship of 10-15 years, there has to be the promise of an opportunity to make a powerful use of the hard-won skills, to make great achievements.

**Access to the world's knowledge** is as important as the generation of new knowledge, if not more so. Often quoted statistics indicate that Australia produces approximately 2 per cent of the world's research output, as measured by publications in international journals. Access to the other 98 per cent, no matter how notional that figure, is obviously imperative. 'Our' 2 per cent will not provide the basis for addressing our problems, for keeping up with major advances in new fields, for identifying new techniques, for understanding the technology employed by our competitors, or for being part of the international research community.

How have we managed this process up to now? Not, to be sure, in a highly coordinated and centrally directed way. But, as with the Internet, it appears that central direction may not be the key to networking. Rather a low control, low reliability, low cost approach may turn out to be the most effective, at least in developing networks in the world of research. Thus our 'knowledge intelligence system' has consisted essentially of the international connections of scientists, through the scientific literature, conferences, and specific collaboration, and the intelligence efforts of companies, which are focussed on overseas parent firms, trade fairs, and conferences.

There is room for the development of a much more explicit 'knowledge intelligence capability' than we have had in the past. The Japanese have pioneered the intelligent analysis, on a global scale, of recorded information of all kinds, in order to identify technological trends and scientific breakthroughs. Alternatively, the Swedish have placed great emphasis on using doctoral and post-doctoral training as an explicit tool to build international connections, and research intelligence networks.

Here is a role for public sector research organisations like CSIRO, and the universities. By the nature of their activities, research staff of these organisations invest considerable energy in establishing effective links with their overseas counterparts, and in ensuring they are up to date with the latest advances. However, this intelligence has largely been confined to the immediate research group. There is a challenge to develop means to make this intelligence more widely available.

**Capturing** (or 'exploiting') **the benefits of knowledge** has been an important motive for the development of the ethos of managerialism in research. The glittering prizes of the stockmarket and control over market share in the new technologically-driven industries have placed a dramatic new premium on reaping the benefits of investment in the generation of or access to knowledge.

At a national level the question of the return on the investment in research has been brought strongly into focus by the pressures of global economic competition. In some countries, particularly the US, there has been a great deal of concern, and some legislative action by government, to restrict those 'free-loading' countries and companies taking 'unfair' advantage of their investment in research. While some knowledge can undoubtedly be privatised, much of it cannot easily be captured through exclusive ownership. Are there ways of ensuring that the payoff of taxpayers' funds for research flows predominantly into the national economy? The globalisation of industry, so aptly captured in Reich (1990) suggests such an approach may be largely unproductive.

In Australia, the emphasis on capturing the benefits of science has been about the commercialisation of research, reflecting the Bush model of technology transfer. This focus on commercialisation, which assumes that economic returns are largely obtained by the transformation of a set of knowledge into a product or service, commonly through a start-up company, can be considered as a first generation response to the recognition of the central role of knowledge in economic activity. The record in both CSIRO and the universities, is of very limited success, and many failures. In most cases there was a failure, or an inability, to assemble the complementary assets necessary to achieve commercial success.

However, with the much richer picture of the interaction between knowledge and economic activity outlined above, commercialisation of research outputs is but one, modest, and very special form of interaction. The second generation, more mature approach, recognises that the majority of the commercial, and social, returns from knowledge generation and management will arise from the effects of knowledge on the performance of existing enterprises. Promotion of a rich pattern of interaction and relationship building, backed up where required by appropriate intellectual property protection, is likely to produce a much larger return on the investment in knowledge generation and access.

The fourth key element of a national science policy is in **providing an appropriate input of knowledge to decision-making.**

The economic pay-off from an effective system of knowledge generation and supply is much more than that realised from new products, and even new industries. It is in providing an informed network for the multiplicity of decisions made by politicians,