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Science policy: Choice among incommensurables and problems of justification

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When New Zealand was at war in the early 1940s the Government exempted from military service certain classes of persons whose work at home they considered vital to the war effort and the country. Amongst those exempted were a "fairly large number of university students taking science courses" (1). After the war the supply of scientists continued to be a problem in New Zealand. Various aspects of that problem have come into prominence at different times: the numbers of scientists trained, the distribution of scientists within the academic disciplines, the ratio of government to industrial scientists, and the balance of effort which is struck with regard to particular problems, have all been considered important.

The governments of Western countries, without exception, have maintained their faith in science. British and American science has been a concern of governments since about the 1930s and war provided the impetus for early government science in both countries. Before that time the institution of science, and technology, were associated with industrial development outside of government. Not that this association was in any way constant in intensity or kind. The mercantile class who ruled Britain until the end of the eighteenth century drew their wealth especially from overseas trade, and their outlook and interest in science was influenced by this. Their successors, the industrialists, were less preoccupied with the ends of the earth and more concerned with home industry. The first to expound the new outlook was Adam Smith (2).

Other authors have shown how the changed attitudes and the evolution of capitalism affected the growth of science (3). At times the relationship between science and industry has led to widespread dissatisfaction with science. During the first half of the nineteenth century, for example, as the factory worker increasingly found himself in competition with machines, machinery acquired an increasingly anti-social aspect which resulted in a stigma on technology and then science.

Science has always rested uneasily with economic development, and an historical perspective should enable those involved in the current debate in New Zealand on science policy and the financing of science to relate their arguments to a broader canvas. Governments will not suddenly remove scientific endeavour from the realm of the public sector, nor will they influence the historical advancement of the central, cognitive aspects of science.

There have, of course, been attempts by governments to influence the course of science. Perhaps the most dramatic was the Soviet Union's attempt to influence the advancement of the subject of genetics. Today it is clear that that attempt only resulted in the retarding of the work of one group of scientists for a short period. The development of nuclear weapons at Los Almos and the US space programme have influenced technology quite dramatically, but in both cases their contribution to the theoretical advance of science has been limited. The space programme, for example, uses Newtonian physics which is of no theoretical interest today (except to historians of science) (4).

It is essential to make a distinction between science and technology when discussing science policy. For "science policy" is, strictly speaking, not primarily about science at all. Science, as it is described by those who study its nature most closely, represents Mankind's effort to understand the physical world (5).

This is in some contrast to technology which is concerned with controlling the physical world (6). The term "applied science" is systematically misleading for it suggests that there exists a discipline which is distinct from both science and technology. This is not the case: the problems which arise and are confronted by professional persons today appear in the context of either Mankind's effort to gain theoretical understanding or his effort to gain practical control of physical entities.

Armed with this distinction the problems of "Science policy" become more manageable. Taking an historical perspective makes them appear less urgent. Hence, with these two points in mind the current New Zealand debate on expenditure in "science" may be examined.

In 1981 the Department of Scientific and Industrial Research's annual report to the

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House of Representatives mentioned for the first time the effects of restraints in Government expenditure. That department had recently, for the first time, developed a set of specific objectives and was about to undertake an even more "intensive review" of projects undertaken. An increase in the numbers of top management took place in 1980 and it was claimed that this was the result of the steady increase in staff numbers which took place over the early 1970s.

There has also been a recent reorganisation of the Ministry of Agriculture and Fisheries research division. Indeed many government departments have been reassessing their priorities and considering science or research policies more closely than ever before, except perhaps at a time when New Zealand was at war.

There has not, however, in the last three years been any growth in scientific manpower in the public sector (8).

These recent developments continue a process which was initiated in 1963 when the National Research Advisory Council was established by Parliamentary Act. The Council was established to advise the Minister of Science on matters related to scientific research in New Zealand. At first the Council restricted its advice to areas where it was thought an increase in research effort appeared most urgent - principally agriculture, forestry, building and minerals - but gradually the Council's activities became more embracing until the social sciences were given a prominent position from the early 1970s. Today New Zealand stands on the verge of establishing a formal science policy. The 1982 Minister of Science and Technology refers to it as the "science plan" (9).

Quantitative information on science policy as it stands at present is only available from one source at present; namely, the expenditure summaries which are developed as a part of the budget cycle. The figures show expenditure in

Table 1. Science budget expenditure, 1981-82

Departmental Activity	Grants and Expendi-ture	Research Subsidies	Contracts	Total
	S(000)	(S000)	S(000)	S(000)
Agriculture:				
Production	57,606	1,092	224	58,922
Processing	3,429	4,068	79	7,576
Forestry:				
Production	11,259	159	36	11,454
Processing	2,896	86	10	2,992
Fisheries:				
Production	6,957	..	30	6,987
Processing	360	42	..	402
Minerals:				
Production	983	10	10	1,003
Processing	355	4	3	362
Manufacturing	9,312	4,396	44	13,752
Building and Construction	1,658	1,083	77	2,818
Transport	3,070	21	..	3,091
Natural Environment	35,603	763	357	36,723
Social Sciences	1,355	2,227	268	3,850
Human Health	2,575	79	..	2,654
Energy	8,597	1,979	694	11,270
Other Scientific Services	4,068	298	50	4,416
Total ...	150,083	16,307	1,882	168,272

various categories and are sufficient to deduce approximately the percentage of total resources which is allocated to a sector such as agriculture, forestry, fisheries, manufacturing or energy research. Table 1 shows the percentage of total expenditure spent on the various activities for 1981-82 financial year and it is based on figures produced by departments. Comparisons can be given, as in Table 2, to establish that New Zealand is not spending as much on research as other developed countries. In addition an OECD summary of R and D expenditure as a percentage of gross national product puts New Zealand at about 0.8 percent, which is slightly below Australia and Canada and well below Scandinavian countries (10).

The National Research Advisory Council has continued to sound warnings to government and the public about the lack of growth in the research effort: 1977 - "The council was concerned that two years of nil net growth could sow the seeds of future problems as the growth of scientific manpower lags behind the increase in those problems that only scientific research can solve."; 1981 - "The last 3 years have been ones of zero growth in science manpower and much effort has gone into reassessing priorities for research effort. Council now believe that continuation of zero growth may be harmful to the economy of the country ...". Other similar statements could be quoted.

At the same time as the accounting information suggests New Zealand is not putting sufficient resources into the development of science, Government statements proclaim faith in and support for science (11).

The systematic collection of accounting information initiated by NRAC has resulted in there being an overview of New Zealand science. Accounting has also sharpened the awareness of what are the central most significant problems of science policy broadly defined. They are traditional problems, but no easier to address for that. They are problems all countries must face and which have general applicability outside of science policy. However, they can adequately be posed in the context of science policy accounting.

Choice among incommensurables

In the 1981-82 financial year $168 million was spent on science in New Zealand. Already some of the uses of this figure have been mentioned. Is it, in fact, sensible to calculate such a figure at all? The conceptual basis upon which such funding decisions are made is largely unexamined in New Zealand and unfortunately it shelters important distinctions which must be drawn if New Zealand is to develop an adequate science policy.

Table 2. Comparative science and technology statistics

	Fiscal Year Beginning	Govt. Funds %	Productive Enterprise Funds %	Foreign Funds %	Other Funds %	As a % of GNP	Per Capita US $	Annual Average per R & D Scientist and Engineer US $'000
NZ	1975	80.2	18.8	-	1.0	0.9	39	33
	1980	77.2	20.0	-	2.8	-	-	-
Denmark	1979	53.3	44.0	1.3	1.4	1.0	125	106
France	1978	50.5	43.7	5.5	0.3	1.8	157	118
Germany	1977	43.3	52.8	2.7	1.1	2.1	181	100
Ireland	1977	50.1	33.0	4.0	12.9	0.8	24	28
Italy	1976	43.5	51.4	1.6	3.5	0.9	29	43
Norway	1978	62.7	33.0	1.2	3.1	1.5	140	88
Portugal	1978	79.5	0.2	0.1	20.2	0.3	6	28
Spain	1974	40.5	57.4	2.0	0.1	0.3	8	34
Sweden	1977	37.9	59.6	1.6	0.9	1.9	184	108
UK	1975	51.7	40.8	4.9	2.5	2.1	85	60
USA	1979	49.7	45.7	-	4.6	2.3	246	86
Canada	1977	46.8	31.5	2.5	19.2	1.1	91	86
Australia	1976	72.6	24.2	1.8	1.3	1.0	71	44
Japan	1979	29.8	70.1	0.1	-	2.1	182	50

Source: Statistics on Science and Technology UNESCO December 1981

NRAC classifies its science budget in two distinct ways: first, by the 16 public service departments which are involved; and second, by activities which are subdivided into a total of 39 usage categories. They explicitly state that these classifications are used rather than a classification by scientific discipline. If the country has no potamologists, phycologists, diacousticists, phenologists or actinists, NRAC is not aware of the fact.*

The point being made is that there are various ways categories may be developed to describe activities or interests, and to select one way rather than another is to exclude the possibility of certain insights. One perspective is selected to the exclusion of many others. In the fanciful example given above, there is still one serious point to be extracted. Is it not possible that in one of the more obscure disciplines of science an insight is gained or a discovery made which has an important "application" in New Zealand? Unless a small country ensures that it has adequate coverage of the totality of human intellectual advance, it is likely that important developments are never applied. This is undoubtedly occurring at present. It is likely, also, that even in areas where the country has specialists, the links to important applications are not always made. Structural features of the organisation of activities work against the utilisation of expertise.

These criticisms, however, refer to outcomes of the present system. The argument being developed here concerns the logic of accumulating unlike entities by bringing them to a common base, in this case "science". The situation is improved conceptually by developing policy around the word "research" rather than "science" - but many of the unfortunate consequences of incommensurable accumulation remain.

In our system of public administration, much of the setting of priorities takes place within the context of the budget cycle. It is here that various projects are set one against another and selection is made between them. Where the alternatives are not of the same logical status with regard to those criteria which are to be used in making the selection, there is no rational way to proceed. In his account of the complexity of scientific choice, Toulmin makes this point and develops it further.

*They are, in the order given, the study of rivers, seaweeds, refracted sounds, the effects of climate on living organisms, and radiated heat.

"... there is a general principle of organisation which holds in the administration of scientific affairs as forcibly as it does in the rest of the public service. This is the Chalk-and-Cheese Principle: namely, that the structure of departments and advisory committees should be so ordered that, at each point, decisions have to be taken between commensurable alternatives." (12)

What Toulmin means is that administration can only be efficient and equitable if the organisation is such that decisions are made within functional categories: the signing of a contract for one power station rather than another power station, the selection of one research project on insulation materials rather than another project on insulation materials. Where these decisions are taken in the New Zealand budget cycle is variable, but in general they would be considered "low level" or decisions of detail. The principle, however, holds when allocations or choices are being taken between more abstract, embracing concepts, provided always that the criteria used to make the choice stand in the same logical relationship to each of the competitors. For example: if your principle of choice is the economic advancement of the country, criteria may be developed from this principle and applied to select between bulk allocations to education or transport votes, provided always that the ministries of transport and education both adhere to the sole objective of the furtherance of the country's economy.

Toulmin found this principle alive and well at the British Treasury Centre for Administrative Studies in the 1960s. There he found that the young assistant principals using the terminology of the Oxford philosopher Gilbert Ryle and "avoiding category-mistakes" (13).

In many areas of public administration the chalk-and-cheese principle is respected, and organisational structures have developed, which, because they reflect the principle, work reasonably well and are generally uncontroversial. The allocation of grants to those who wish to develop marginal farm land is a good example. The criteria of economic viability can be applied to cases on their merits. It is not surprising that when it is suggested that other, possible irrelevant, criteria are being applied, the allocation of grants for the development of marginal land becomes controversial. Such a controversy is distinct from that which surrounds the question of whether it is in any case appropriate to advance our country's economic state by providing grants for the development of marginal land.

In the case of science policy it is possible that items are being aggregated which are incommensurable.

The distinction between science and technology has been made. NRAC once recognised this distinction:

> "Research directed to the increase of scientific knowledge may be termed 'basic research' for it forms the foundation upon which all applications of science depend." (14)

Aside from the question of whether this statement is true, it is important that NRAC recognises that basic research has an important place in the development of scientists and the achievement of the country's objectives. Rightly, they mention that basic research is the appropriate function of the universities. Later, they claim that there is basic research needed in a number of specific areas and quote fields such as systematics, biophysics, seismology, and surface chemistry.

The science budget funds such work. Unfortunately there is no separate accounting of this in the categories used by NRAC. The justification, for, and implications of, basic research are quite different from those of "applied research" or what is probably more properly called technology.

It is probably carping to mention the inconsistent way NRAC used the term "basic research" in 1967, but it is indicative of their lack of clarity about the concepts. They call for basic research into facial eczema, grass grub and bloat in cattle when it would appear that what is really sought are methods to control all three problems. The control of eczema, grass grub and bloat is considerably more important to New Zealand than the theoretical understanding of the various sciences which are involved. Technology solves the practical problems and frequently it moves well ahead of theoretical insight (14).

<u>The justification of expenditure on "science"</u>

An OECD consultant group on new concepts in science policy developed a notion of science policy which has enjoyed wide application in Canada, Australia and New Zealand (15). OECD stated:

> "Science policy does not only include policy for science - that is, for the creation of an environment in which science can flourish and choices can be made among scientific and technological projects and fields; it also comprises science for policy - affecting the ways in which scientific and technical considerations bear on important political decisions and policy choices in areas that are not themselves mainly scientific, such as foreign affairs and urban planning. (16)

New Zealand science planners endorsed this concept in 1976. Yet, it has been the recent reviews of expenditure which have brought those involved to a re-examination of expenditure on research and the priorities for reseach funding.

The Annual Report statement of the Department of Scientific and Industrial Research which supports the above paragraph has been mentioned along with other evidence. Now the question being asked is: what form of justification is offered for expenditure in these and other similar documents?

There has always been such rhetoric on the worth of science and, as indicated previously, when the country faced real difficulties, support for science was given a high priority.

From its inception NRAC has been issuing statements which may be read as justifications for expenditure on science: "funding research is an act of faith - investment now for a greater future return." (1982); "The council believes that now more than ever before there is an opportunity for science and technology to make a great contribution to the economic well-being of the country." (1980); "...New Zealand relies on applying science and using modern technology in the primary, manufacturing, and transport industries to maintain and develop a competitive economy in today's world." (1978); "Scientific research may be regarded as a long-term investment. The amount of money at risk is small. The possible returns could be dramatic." (1967); "The council has no doubt about the value of research to national development." (1965).

It would appear that the only justification NRAC has placed before the House of Representatives for investment in science is the "overheads" doctrine. This was formulated by Kaysen in 1965 thus:

> the fundamental justification for expending large sums from the federal budget to support basic research is that these expenditures are capital investments in the stock of knowledge which pay off in increased outputs of goods and services that our society strongly desires. (18)

The doctrine has been supported recently by a statement from the 1980 Minister of Science and Technology, Mr Birch. This was printed by NRAC:

> As a result of discussion with your Council on 29 July 1980 and my review of DSIR activities this year, I am firmaly of the view that your Council cannot advise me collectively on research and development (R and D) policy and priorities without a formal statement of Government economic development objectives; and that such a statement must be communicated to everyone involved from your Council members down to the individual scientists at the 'bench level'. (19)

This is an authoritarian model which New Zealand (and most other) governments have used successfully in many areas of activity. Progress is made by working out the objectives, dividing up the tasks and communicating information and direction on tasks and objectives down the pattern of line management. NRAC confirms:

> ... a major task remains ahead of the council: how to translate the Government's statement of general objectives into a balanced, efficient R and D programme. (19)

and:

> The Government's objectives will be handed down through NRAC to science managers, and the council and its committees will review overall programmes in terms of their contribution to these objectives. (19)

The New Zealand statements suggest a much tighter relationship between government objectives and science than appears in Kaysen's statement. The New Zealand approach may well be successful for developments in technology - where an outside agency can direct which physical objects be developed, or which practical problem should be given priority - but the theoretical problems of science can only be identified by those who understand the theory and can recognise its limitations.

It is possible to argue that the selection of areas of theoretical research should be decided by the state while the specific problems selected be left to the scientists. This would be possible, but in practice the directions would be at such levels of generality as to be of no real significance.

A further point, implicit in the above argument, is that it is not possible to determine in advance which scientific enquiries will be of use. (Note: "will be of use" is not the same as "will be applied" or "will have practical application". This distinction is important.)

The overheads doctrine is but one account of why the state should be concerned to support science. Very briefly two other accounts may be mentioned. Neither of these accounts have been argued in department reports. They are the "high civilisation" doctrine and the tertiary industries economic argument.

The high civilisation doctrine places science (but perhaps not technology) in the same category as art, as far as the economy is concerned. The rise of both Greek science and modern science coincided with cultural "revivals" and before recent times scientists were not professionals paid to work on scientific problems.

The view of art as something essentially frivolous or decorative is a late nineteenth century one. It is still necessary, however, to argue the case: why are art and science important to human beings qua human beings? The nature of Man is now at stake and if understanding (in its collective sense) is considered important here, science may be placed in an excellent light.

Another possibility is to regard science as belonging to a different economic category than that usually assumed. This position is the parallel economic argument to the psychological sociological argument given above. Johnson wrote:

> The consent of 'scientific culture' raises a number of questions, among which the most fundamental is the question whether basic scientific research is - in the economist's terms - to be regarded primarily as a consumption or an investment activity. (20)

Science viewed in this way is economically only important in that it generates demand for spending. Recently, in New Zealand, education has been considered in a similar way.

As opportunities for employment lessen, and there is concern about the demand for goods and services, tertiary industries become of increasing importance. Those tertiary industries which have the potential of leading Mankind and the host country to unexpected advances should be encouraged above all others. This places science in competition with the entertainment industry, for example.

It is also necessary to ask whether the justifications apply to university, DSIR, or private science. As far as government money is concerned, given that this is by far the largest source of New Zealand science funding, diversity of institutions is probably best maintained and strengthened.

Conclusion

An attempt has been made to show how accounting serves a useful function in bringing into debate serious, far-reaching issues. Certainly, in New Zealand, this has recently occurred. To address these issues, specialist knowledge is needed of such diverse subjects as the philosophy of science, the philosophy of technology, public policy and economics. When accounting (be it in science or elsewhere) raises problems of incommensurability, topics from the discipline of logic are at stake.

In this there is a strong argument which can be made for accountants being involved with a very diverse group of people, all of whom have something to contribute to the policy-making process.

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International cooperation in science

Extracts from an OECD Report

. . . for several centuries now, cooperation has been an active and everyday aspect of scientific life, through the exchange of scientists, the spreading of specialised literature, the publication of discoveries and the critical discussion of experience and ideas. Cooperation has been, and still remains, an essential instrument of the progress of knowledge.

For those countries which have only a limited number of scientists, the need for access to the international scientific community is even more pressing.

Although science is a language that knows no frontiers, research is financed by national resources and carried out by men or teams competing with one another, and its results are used by States and enterprises whose mutual relations are based first and foremost on competition. International scientific and technological cooperation is therefore not a spontaneous phenomenon but the result of a dual approach, political on the one hand, and scientific and technological on the other. In each case, the impetus will be provided by one or other aspects; but however justified a project may be from the scientific and technological point of view, it will never come to fruition if foreign policy considerations are opposed to it, and conversely a form of cooperation thought up solely for foreign policy reasons will never be successful if it does not comply with the inner logic of scientific and technological activities.

. . . all Member countries' governments are fully convinced of the need for strengthening or re-establishing their industrial capabilities through active encouragement of innovation, and are preparing policies in this direction. Although such increase in innovation performance will, at the same time, contribute to international competitiveness, there is in varying degrees an increasing interest in the contribution of innovation policy to increasing world-market shares at a time of slow growth and high unemployment and balance-of-payment difficulties. It is also noted that almost all countries that have established priority areas for the support of industrial R & D have established the same list of priorities, which might lead to excess capacity in some areas with possible consequent increase in protectionist tendencies.

Many of the impacts of technology tend to be driven by competition, and increasingly by international competition. An extreme example is, of course, the nuclear arms race, but the situation seems to be equally true of the evolution ofinformation technology, of applications of the "new biology", of nuclear power, of the automobile and of air transport. If competition alone is left to govern evolution in the application of new technologies, it is quite likely that the detrimental effects will grow out of control, since they are only weakly reflected in the competitive influences, whether they be political or economic. Thus, an essential task for international consideration is to frame new ground rules which limit the detrimental impacts compared with where they would otherwise be driven by competition, and to do this at an early enough stage in the development before vested interests and competitive momentum make such ground rules impossible to enforce. Here is where the role of internationally orchestrated technology assessment is so vital.

There are three cogent reasons for increased cooperation between Member countries:

1) increased research costs and the levelling-off of national expenditures on R & D;
2) the pressure of problems and challenges common to all (energy, natural resources, the environment, public and social services);
3) the "transnational" character of many research fields which are of concern to most, if not all, Member countries.

At the same time however, one must accept the fact that all countries are increasingly concerned with strengthening their competitive position and that this has become one of the prime objectives of their science and technology policy.

The international research programme should be a breeding ground for top national specialists.

The mechanisms of cooperation in science may vary considerably, depending on whether the cooperation takes the form of simple exchanges, a common research programme shared between national teams, or research (often on "big science") carried out in a joint laboratory.

The international programme should not compete with national programmes (and financing); on the contrary it should complement them. Conversely, it is important that there be national efforts by participating countries to adapt to and make use of the international programme.