W.0328 2 May 1984

PRIME MINISTER

MEETING ON THE SCIENCE BUDGET, 18.00 hours, 3 May

Sir Keith Joseph suggested to you that it would be valuable if you could talk directly with the people concerned with the difficult issues of priorities within the Science Budget. After discussion you and he agreed that two separate meetings would be desirable;

(i) a small meeting about priorities and the processes by which the science bodies arrive at them;

(ii) a meeting with active scientists on recent scientific advances and the kinds of opportunities which they open up.

2. The second meeting is to take place at Chequers on 8 July. This brief covers the first meeting which takes place tomorrow. Present will be Sir Keith Joseph, Mr Peter Brooke, Mr David Hancock, Sir David Phillips (Chairman of the Advisory Board for the Research Councils) and Professor John Kingman (Chairman of the Science and Engineering Research Council).

Background

3. The size of the Science Budget for 1984-85 is £550 million. The sums for the five Research Council are as follows:

AFRC - £46 million (plus about £50 million for commissioned research)
MRC - £117 million
NERC - £65 million (plus about £20 million for commissioned research)
SERC - £279 million
ESRC - £22 million

Small sums went to the National History Museum, the Royal Society and the Fellowship of Engineering. The Councils account for roughly 1/8th of central government spending on R&D and 1/4 of civil R&D expenditure of about £2 billion. Defence R&D expenditure is also about £2 billion.

FLAG A

4. The trend of the Science Budget is shown in Annex 1. The figures allow real increases of £6 million in 1984-85, £8 million in 1985-86 and £7 million in 1986-87, to assist with the increased costs of international subscriptions, and £0.5 million each year to assist with restructuring costs. The DES argued unsuccessfully in last year's PES bid for a £98 million increase in spending spread over the next 3 years, on the grounds that these funds were required to support new work in fields such as the application of advanced technology to manufacturing engineering, food and nutrition, spectroscopic measurement of cosmic X-ray sources, neurosciences, biotechnology, deep geology, marine sciences, remote sensing and atmospheric sciences; also to provide for additional funds to obviate the one-in-five (and growing) rejection rate of first-rate ("alpha") grant applications and to assist in restructuring Research Councils to improve flexibility. The increases proposed represented about 4 per cent in 1984-85 and 7.5 per cent in 1986-87. It was claimed that our main competitors in the world markets are planning to increase their spending in basic research by 18 per cent (France), 8 per cent (USA) and 5 per cent (W Germany).

5. Because the PES bid was unsuccessful, the ABRC has decided to make possible the restructuring of AFRC and NERC by diverting research funds from the MRC and SERC. The total sums diverted will be some £3 million in 1985-86 and £6 million in 1986-87.

The ABRC also consider that it may be necessary to withdraw from a major area of science in order to allow greater scope for responding to new scientific opportunities. You have agreed to a review of the UK's participation in high energy particle physics to be carried out jointly by the ABRC and SERC. The review will be chaired by Sir John Kendrew. The £45 million pa expenditure on high energy particle physics is concentrated at CERN in Geneva.

6. An average of 25 per cent of Research Council budgets is spent on research grants to universities (AFRC 10 per cent, NERC 11 per cent, MRC 24 per cent, SERC 32 per cent).

7. The Science Budget is one part of the "dual-support" system of research at universities. The other part comes from the UGC block grant for teaching and research. There is no good current estimate of how much of this grant is spent on research. A 1970 estimate that there was then a 70/30 split between teaching and research would give a current research support figure of about £660 million - this is certainly an overestimate, perhaps substantially so. The UGC cuts on university grants seem to have fallen disproportionately on research.

8. There are many definitions of basic, strategic and applied research but I suggest we work to the following:

> Basic research is that undertaken primarily to acquire new knowledge, without any particular application in view.
>
> Strategic research covers the area where basic concepts are established, but where it is not yet possible to identify specific products or processes.
>
> Applied research is directed towards a specific practical aim, such as the development of new products or processes.

Handling

9. Sir Keith Joseph will wish to make a brief introductory statement on the origin and purpose of the meeting - a welcome opportunity for the scientists to tell you directly what they tell him. You should then ask Professor Kingman to speak on priorities and opportunities in SERC. Sir David Phillips will follow with comments on the other Research Councils and on ABRC.

FLAG B

10. I could then comment briefly on the possibility of redeployment of the Government's £4 billion R&D spend between Departments. Annex 2 indicates how this is currently spread between basic research, R&D in support of procurement, R&D in support of industry and R&D for Government's own needs, eg policy formulation, statutory and regulatory obligations. I shall be supporting Treasury in their PES discussions, using data gathered from the 1984 Review of Government R&D.

11. You may then wish to question Professor Kingman and Sir David Phillips on their contributions. I suggest that the discussion might be divided into two parts:

(i) Are the Research Councils efficient and effective in setting priorities and implementing them?

(ii) Are the Research Councils using the right criteria for setting priorities and what sorts of opportunities are being lost with the abandonment of lower priorities?

12. Efficiency and effectiveness in setting and implementing priorities

Possible issues are:

(a) Is the "peer review" system the best? How much does it cost? Does it lead to the support of established scientists at the expense of bright young ones? Does it penalise interdisciplinary areas where

much of the most exciting science is being done?

(b) Are the Research Councils spreading their resources too thinly? How many Departments of Chemistry (say) are doing really good research? Is there too much support going to the others? Are the UGC and the Research Councils consistent in their support of the best research in universities?

(c) Are the Research Councils working well with Government Departments in their respective responsibilities for research? Is there overlap and duplication? Are there gaps - for example, why do we know too little about the science of acid rain at a time when there is a strong demand for action?

(d) Is the organisation of Research Council staff a limiting factor in stopping worked out areas of research and putting resources into new areas? The MRC seem to have a smaller proportion of tenured staff (70 per cent) and greater flexibility in closing and opening research units than other Research Councils; is this an example to be followed?

(e) Are the Research Councils sharing large equipment internationally to save costs? Can we control international facilities or are they all as gold-plated as CERN? Do we share telescopes, research ships, satellites, or only reactors and accelerators?

In folder at D Page 15 onwards are relevant

(f) Is ABRC just a bureaucracy as Sir Douglas Hague suggested in his Mond lecture? (You have seen Sir Douglas's lecture in which he concluded that ABRC needed to change, and that its bureaucracy needed to change - that a "learning" bureaucracy needed to be devised. He recommended that a small strategy unit be established, to challenge orthodoxies, to ensure change actually happens and to develop a 'top-down' view. The unit would need to monitor economic, technical, social and political developments outside

science, as well as activities in universities and Research Councils. Members would need to come from outside the Civil Service and the community of natural scientists and engineers - perhaps from economics, and certainly from business schools. You may wish to seek reactions to Sir Douglas's views.)

13. Criteria for determining priorities

Possible issues are:

(a) What balance of criteria are the Research Councils using? Scientific excellence? Prestige? Economic value to the nation? (Annex 3 shows the criteria which the ABRC "invited" Councils to use in 1975. Under the Science and Technology Act, 1965, the Secretary of State for Education and Science has powers to give directions to the Councils in relation to their activities financed out of the grant-in-aid).

(b) Is the likelihood of successful exploitation of research results a significant factor in choosing research projects? We seem to lead the science in many areas but fail to exploit it - are we doing as well as we should in medical instruments based on Nuclear Magnetic Resonance, for example?

(c) How do the Councils see their responsibilities for strategic research? (Lord Whitelaw reported the concern in the recent House of Lords debate, which echoed Sir Ronald Mason's recent report to ABRC, that strategic research was being squeezed out between Government Departments concentrating on applied research and Research Councils concentrating on basic research).

(d) 90-95 per cent of the world's R&D is done outside the United Kingdom - what criteria do the Councils use to place their limited resources in the world context?

14. Conclusions

Since this is the first of two meetings for information, there is no need to come to specific conclusions. You may wish to make some general comments: my expectation is that the Councils will be able to demonstrate that they have taken action and have further action in hand to make their setting of priorities and implementation of these much more efficient and effective. However, their criteria for setting priorities may still be woolly and insufficiently in tune with the country's needs. Nevertheless they will probably be able to demonstrate that important opportunities are being lost. You could say that you are looking forward to the meeting on 8 July and hearing more about the exciting science which is being done in the UK.

RBN.

ROBIN B NICHOLSON
Chief Scientific Adviser

Cabinet Office
2 May 1984

cc: Sir Robert Armstrong

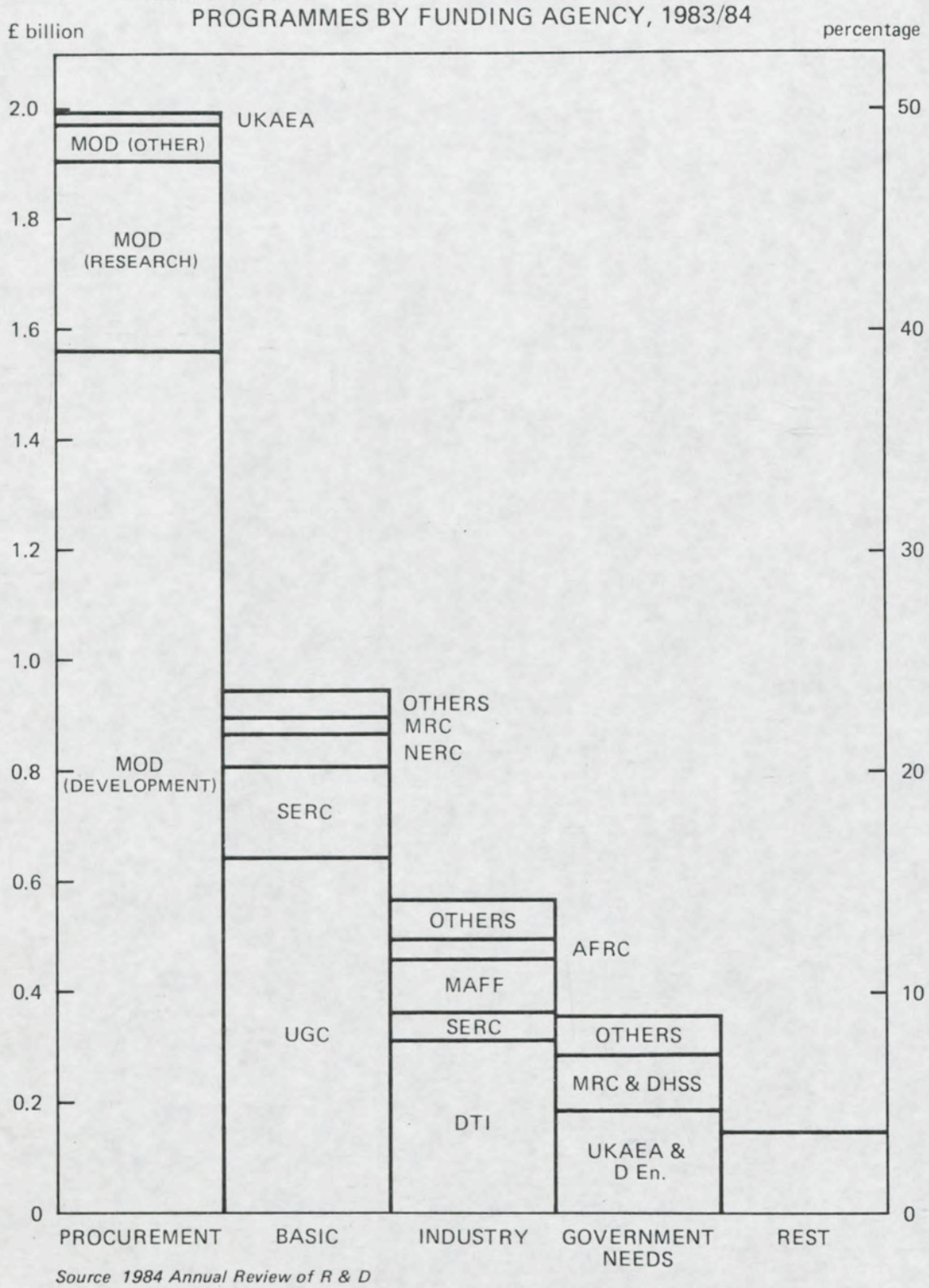
ANNEX 1

THE SCIENCE BUDGET 1984/85 TO 1986/87

£m cash

ALLOCATIONS	ESTIMATED OUTTURN	PROVISION	PROPOSED	
	1983-84	1984-85	1985-86	1986-87
AFRC	46.0	46.5	45.7	47.0
MRC	113.7	117.2	120.2	122.8
NERC	62.5	65.9	67.5	69.6
SERC	254.5	278.8	291.9	298.9
ESRC	22.4	22.0	23.0	23.7
NHM	9.4	9.75	10.15	10.45
Royal Society	5.0	5.3	5.7	5.85
Fellowship of Eng	-	0.15	0.15	0.15
Restructuring	-	-	4.0	7.2
Science Policy Studies	-	-	0.05	0.05
Sub-total	513.5	545.6	568.35	585.7
NHM (PSA)	3.3	4.4	5.1	5.7
TOTAL	516.8	550.0	573.45	591.4

PRIMARY OBJECTIVES OF GOVERNMENT FUNDED R & D PROGRAMMES BY FUNDING AGENCY, 1983/84



Source 1984 Annual Review of R & D

Note: For comparison, it is likely that private industry will have also spent around £4 billion on R & D in 1983/84, of which around £100 million will have been on basic research. Accurate figures are not, however available

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APPENDIX IV

THE COMMON CRITERIA

(see Appendix I, para. 7)

1.* Councils and their Boards/Committees/Groups are invited to use the criteria listed here to discuss and compare relative benefits. Whenever practicable, reference should be made to objective data in support of the assessment (eg demographic data; social costs; relevant government expenditure etc.) in relation to the cost of the research.

Scientific Policy Criteria

(1) Excellence of study field
Where benefits are attributable to a high proportion of the research being intrinsically of high intellectual value.

(2) Excellence of the research workers
Where benefits are attributable to the exceptional quality of the individuals or teams to be employed in the activity.

(3) Pervasiveness of the activity
Where benefits include the impetus to advances in other and related fields of science in addition to the primary field.

(4) Social and/or economic importance
Where expected benefits arise from the work being directed to supporting social or economic aims.

(5) Significance for the training of scientific manpower
Where benefits will include training and experience for scientific research workers.

(6) Educational importance
Where benefits will include a contribution to education.

(7) Significance in maintaining national scientific prestige
Where benefits will contribute to national reputation.

Management Criteria

2. A set of selected management criteria are also offered. These apply to the consideration, from a management policy point of view, of alternatives which have already been assessed on the scientific policy criteria.

A. Efficiency of operation
Where improvements in organisation and/or plant would lead to a general increase in efficiency.

B. Obsolescence
Where the maintenance of a capability (at whatever level of activity) requires replacement within the Forward Look period of a major item of obsolescent plant or equipment.

C. Timing
Where a start on a new or increased activity within the Forward Look period is critical if the expected benefits are not to be lost or much reduced.

D. Dependence on Science Budget Support
Where there is likely to be limited support, national or foreign, available for work related to the activity except the Science Budget.

E. Availability of scientific manpower
Where an activity attracts priority by virtue of greater availability of scientific manpower for it (or its execution is constrained by lack of it).

F. Scope and limits of redeployment
Where the priority accorded to an activity is conditioned by difficulties or opportunities of redeployment.

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* Extract from instructions to Research Councils, 1975 Forward Look.

W.0329 2 May 1984

MR TURNBULL

PRIME MINISTER'S DISCUSSION ON THE SCIENCE BUDGET

I enclose a brief and handling notes on tomorrow's discussion. Also attached is a copy of the 1983 ABRC advice to Sir Keith Joseph. I recommend that this is not given to the Prime Minister because of its length but it may be useful for you or the Policy Unit to have it handy.

RBN

ROBIN B NICHOLSON
Chief Scientific Adviser

Amended

IS SCIENCE MANAGEABLE?

The Mond Lecture - Delivered by Professor Sir Douglas Hague at Manchester University on 12 March 1984

Last June, I went on holiday to Scotland assuming that I should come back to run courses in Oxford for top managers. When I returned, two weeks later, I had agreed to become Chairman of what is now the Economic and Social Research Council. Thereby hang at least two tales, but I do not intend to tell either this evening.

The third tale I will tell. I realised of course that in my new role I should have responsibilities covering the whole of the social sciences. What I had not appreciated was the extent to which I should be involved with the natural sciences, engineering and medicine. In particular, chairmanship of my Council involves membership of the Advisory Board for the Research Councils (ABRC), which is responsible for advising the Secretary of State for Education and Science on the total size of the Science Vote and on the way in which it should be divided up between the research councils. As a result, I have become directly involved in the difficult problems of the funding and organisation of scientific research in the UK.

I regard it as a great honour to follow so many distinguished scientists in giving this lecture. I am equally honoured to have been asked to give it by the University of Manchester, an institution for which I have nothing but admiration and respect. I spent nearly twenty very happy years here during the period when we set up Manchester Business School, establishing it as one of the leading business schools in Europe and indeed the world.

Given that experience, I naturally looked at the working of the ABRC with the eyes of a management scientist, something which seems never to have happened before. What struck me at once was that we were concerned with what, to me at least, appeared managerial questions. Yet we were not seeing them as such. I went back to reread C P Snow's The Two Cultures. Snow, you will remember, spoke of "two groups - comparable in intelligence, identical in race, not grossly different in social origin, earning about the same incomes, who had almost ceased to communicate at all".(1)

(1) CP Snow, The Two Cultures, University of Cambridge Press, p2, 1964 edition

He later said "The degree of incomprehension on both sides is the kind of joke which has gone sour.".(2)

Like Snow, I still see a clear difference between the way that scientists look at issues and the way that I do. I would not, however, regard myself as belonging to the arts culture. While Snow contrasted the cultures of science and the arts, one of the points on which he was most criticised was the implication that there were two cultures only. He pointed out in the 1964 revision of The Two Cultures, that the only word in the title which was not attacked was 'The'. As he says, the implication was that the title Two Thousand and Two Cultures would have been better. Snow insisted that the number of significant cultures really is very small. He was, however, prepared to accept that there would be soon, if there were not already, a third culture - that of the social sciences. Snow himself here included social history, sociology, demography, political science, economics, government (in the American academic sense), psychology, medicine, and social arts such as architecture. Though recognising that it was "a mixed bag" he saw "an inner consistency. All of them are concerned with how human beings are living or have lived.".(3) I should myself make a further distinction. That is between social sciences like economics and sociology and professional subjects like accountancy and law. Management - which is to be a major topic this evening - is a hybrid. It draws heavily on those social sciences that can be used to help analyse the business environment and the elements in business problems. It also draws on mathematics, accountancy and law which have more specific contributions to make - especially to business-decision taking.

The social sciences still have a long way to go before they can be recognised alongside the natural sciences, not least because one cannot easily carry out valid experiments. Nevertheless, the outlook and the approach to problems which the social sciences have given me over the years provide a distinctive approach to problems which is that neither of the scientists nor of the mainstream arts man.

Perhaps what brought home most clearly the great divide between the thinking of the natural scientist and the social scientist was this. For reasons

(2) ibid, p11

(3) ibid, p70

I do not need to go into, I recently circulated a short paper on the role and activities of the ABRC to a number of scientists to get their reactions. Almost to a man, they insisted that they found what anyone from a business school would regard as a totally conventional approach, as verging on the incomprehensible.

The fact that the inhabitants of these "cultures" have difficulty in communicating would be less serious if we did not live in a rapidly changing world. It is during periods of rapid change that we most need to communicate about what is going on and least succeed in doing so.

The changes are complex and interconnected. They are difficult to understand and to explain. For today's purposes I believe we can make sense of what is going on in the UK if we pick out three.

First, and most important, we are entering a period of rapid technological change. There are bound to be independent economic and social changes, but I believe that much of the change in the 1980s will be driven by technology, not economics. Walt Rostow, the distinguished American economist/economic historian describes this as the fourth industrial revolution - the information revolution. Around 1970, we came to the end of Rostow's third industrial revolution - that associated with oil as a fuel, the motor car, consumer durables (like domestic equipment, radio and television), plastics, man-made fibres, etc.

Rostow's fourth revolution will do two things in particular. First, it will enable us to refurbish manufacturing industry. Older industries like steel, automobiles and engineering will, by using robots, increase output per man and reduce costs to stay competitive even with industry in countries like Japan and South Korea. Second, a new range of high-technology industries will develop, many concerned with the information revolution. I think especially of consumer electronics, electrical activities like the production of cables, switching equipment and micro-wave communication equipment, as well as aerospace, especially communication satellites. We can also look forward to dramatic developments in biotechnology. The fourth industrial revolution may also see the development of alternative sources of energy.

We are, in more senses than one, in a period like the 1930s. As then, the industrialised world faces high unemployment. As then, though we have less excuse, economists are profoundly gloomy about the possibility of creating future employment. In the 1930s, they talked of secular stagnation, implying that economic history had come to an end. Everything that was to be invented already had been invented. I well remember, when I was a student in the 1940s, how writers on economics insisted that all we could do was to spread the existing standard of living to the last Chinese coolie. Then, "The economic problem would be solved.". Even Keynes mistakenly wrote of "making capital cease to be scarce within a generation". He (and they) had misread the importance of technological change.

The reason why economists got it wrong then was that they largely ignored science and technology. That is why most economists still get it wrong today. Whether disciples of Keynes or Friedman, they are obsessed with how to manage national demand. Problems of supply - and especially the role of technological change - are largely ignored. The writings of Schumpeter, the Viennese economist who stressed the role of invention and innovation in economic development, go largely ignored by professional economists. We let the 1950s and 1960s take us by surprise. There is no need to let the 1990s do the same.

I am therefore more optimistic now that I would have been in the 1930s. I see - as other economists should have seen both then and now - a new wave of technological development, leading to more rapid economic growth.

But I may be wrong: not about the fourth industrial revolution - which is a certainty - but about our ability to take advantage of it in a changing world. This is the second important change which is affecting us. In the 1950s and 1960s we were able to create jobs and prosperity throughout Western Europe by cashing in on the third industrial revolution. We did so because Western Europe and the United States dominated the industrialised world. This is no longer true.

The area of most rapid industrial development in the remainder of this century will be the Pacific. There is not only Japan, herself a formidable-enough competitor, but also of other newly industrialising countries. Not least, there is what Paul Samuelson calls the 'Gang of Four' -

Singapore, Hong Kong, Taiwan and South Korea. We in the West will not have the fourth industrial revolution to ourselves in the way that we did the third.

Also on the international front there is the problem of oil. The two big oil price increases in 1973-74 and 1978-79 diverted both demand and wealth from the developed countries to OPEC, and especially to the oil producers around the Arabian Gulf. The economic problems this has caused have been serious. However, since they are basically problems of finance and demand they are not germane to this lecture because I am concentrating on technology.

The third element I wish to highlight turns out to be the joker in this pack. It is what has come to be called the post-industrial society. There seem to be two schools of thought about this. The first, wracked by fears of a "deindustrialisation" denounces the notion as unthinkable or, should it nevertheless become a reality, undesirable. The second group accepts the post-industrial society as inevitable but, with few exceptions, fails to understand it.

This has been forcibly brought home to those willing to listen by work in the Science Policy Research Unit at Sussex University. In particular, there is an important book Social Innovation and the Division of Labour by Jonathan Gershuny. Gershuny characterises the conventional view of economic development as comprising "a march through the sectors". Economies begin by concentrating on primary production - agriculture and minerals. They then move into the industrial phase where the primary sector provides food and raw materials for an industrial sector which dominates the economy. Then, in the post-industrial society, the industrial sector shrinks and, in turn, domination of the other two sectors by service activities begins.

Gershuny points out that what actually happens is much more complicated. He does not quarrel with the characterisation of what happens in the primary sector. It is one which, as economic development takes place, represents a smaller and smaller proportion of both output and employment. The complexity arises over the relationship between manufacturing and service activities, which are not separate, but linked. When the conventional wisdom talks of services it confuses two things. First,

there are final services. Those in the private sector include restaurant and hotel meals and accommodation, like haircuts, entertainment, etc. In the public sector are the services which we normally refer to as the 'welfare state'. All of these are final services.

This conventional wisdom leaves out two things. First, there are what Gershuny calls intermediate services. Thus, for example, when we pay for a motor car we buy not only the product itself but also the services of large numbers of people carrying out service activities - people working in garages, or showrooms, in advertising etc. There are also consumer intermediate services providing advice, equipment and maintenance to households. For example, these maintain washing machines, refrigerators, TVs, videos and will in future deal, for example, with computer programmes. This must be a major growth area during the remainder of the century.

While you may not have thought of all this complexity for yourself, none of it will strike you as surprising. Here, however, Gershuny adds a new twist to the analysis. First a slight digression. We can distinguish four types of occupation. First, there is formal employment by an employer: what we call "work". Second, there are three types of informal activity. Some of this activity takes place inside the household, with members of the family working for others; some takes place within voluntary organisations; and some takes place within the underground, or "black" economy.

Gershuny's twist relates to the household, which is much the most important of these informal sectors. As economies become richer, economic forces mean that a growing proportion of the population does not buy final services directly from those in formal employment. Instead, individuals and households provide many services for themselves - doing their own cleaning instead of using domestic servants; cooking meals instead of going to restaurants; transporting themselves by car instead of using buses or trains; and so on. Indeed, Gershuny's twist goes further. In order to provide most of these services the household will have to buy capital equipment - what we call consumer durables. The capital equipment is then used in the informal not the formal economy. This has two results. First, output in manufacturing industry is higher

than one might suppose when one is talking of a shift towards service activity. Second, there is a shift from formal to "do-it-yourself" employment in the household. Employment and unemployment figures are no longer quite what they seem. We can choose either to work longer and then buy more final services directly, but usually expensively. Or we can work less long, earning enough to buy vacuum cleaners, washing machines, lawn mowers etc and then take off sufficient time to do our own housework and gardening.

Now that Gershuny has pointed all this out so clearly, we can recognise that we have been moving through this kind of phase for some time.

The fact that we have passed substantially through the phase where we were buying consumer durables, television sets and videos means that the products of the new industrial revolution are appearing at a time when a new market is conveniently opening up for them. We could not have afforded to spend money on micro-computers, cable television, etc if we were still buying motor cars, TV sets or videos.

To sum up, the post-industrial society will be a very complicated one. There will be markets for the products of high technology industry both in business and in the household. You must expect the information revolution to lead, as the consumer durable revolution has done, to competition between the household and final services - even final services currently provided by educational institutions. It will be possible to receive much of the education currently provided by a university while sitting at home with a TV set, video and mini-computer. Perhaps too few of us have taken on board the fact that the information revolution will compete with apparently quite disparate activities. I suspect that the universities are going to find it immensely difficult to come to terms with the information revolution.

One can put the situation in what is undoubtedly an over-simplified way, but one which should give us pause for thought. We may say that the problem for manufacturing business is that it will have to compete with the Pacific. The problem for service industries is that they must compete with the household. The problem for the universities is that they will have to compete with the information revolution.

As you know, I gave this lecture the rhetorical title, Is Science Manageable? I want to make clear at once that the word "science" certainly includes

technology. Beyond that, I think I have shown already that scientific, and especially technological developments during the rest of this century will pose threats and challenges that will be extremely difficult to manage.

In answering my question, I could clearly address myself to all or any of a huge field. Since I am speaking in a university I propose to answer the question with respect to two particular fields. First, can those of us who have to do the job "manage" the educational system in such a way that Britain makes a success of the fourth industrial revolution? Second, at the national level, can those of us who are responsible for individual research councils or for the research councils as a whole "manage" what we are doing there?

So far, I have not tried to say what I take the word management to mean. In particular, what is it that management education can and does teach us? Professor Leavitt, an eminent American management scientist, gave the Stockton Lecture at the London Business School, last year. I agree with him in seeing management education as having gone through three phases. I speak only of the UK, though he spoke of the USA as well. One phase, which in Britain had its heyday in the 1960s and early 1970s, put great emphasis on techniques, often mathematical, which permit rational decision taking. These techniques were relatively easy to teach and learn because, being formal, they could be taught formally in the classroom or read about in a book by even those with fairly limited mathematical knowledge.

Two major problems arose from this. First, the analytic problem solvers thus produced were mainly economists, accountants or operational researchers and they thought on the grand scale. They could decide on the optimal way of operating a large system, for example by using computers to apply linear programmes. Some of them even believed that a very large number of human beings in an organisation could be replicated and managed equally well by those who applied rational thought.

As Leavitt points out, this kind of expert - whether in a business or a business school - found it difficult to cope with a second group of people - the implementers. The implementation phase began earlier than the decision-making phase, and is still with us today. Those concerned

with implementation - mainly psychologists and sociologists - did not live too easily with the problem solvers. The problems solvers saw reason as good and emotion as bad. And they saw the implications as excessively concerned with emotion. There was therefore a conflict, though it has probably proved fruitful and productive, rather than the opposite.

Inevitably, the rational analyst takes the view that one first decides on the solution to a problem and then decides to implement it. That is what many of the management text books say including, I must admit, my own. But the fact that business schools tended to produce either those who specialised on planning and decision making or those who were concerned with emotion, working and implementation led to problems. I quote Levitt. "Although it makes logical sense to solve the problems first and then to implement the solutions, it does not make psychological sense to do so within organisations. The reason is that in organisations many human beings are always involved in the process. If the human bodies doing the problem solving and the decision making are a different set from the bodies assigned to carrying out the decisions, trouble will follow."

Problem solvers, of course, are unhappy about this, as I frequently discovered when chairing meetings in the Business School. Being "democratic" in decision making slows everything down. Moreover, the decisions, being committee decisions, may well be mediocre. The decision makers complain that good, clear decisions which they propose are ruined by the trade-offs and compromises of the implementers.

As time passes, I believe that these tensions are being reduced. In particular, I believe that the business schools are beginning to produce graduates who have the qualities both of the problem solver and the implementer. Perhaps one reason is that the success of the Japanese both undermined the self-confidence of the problem solvers and showed the importance of good implementation.

The information revolution is helping as well. In both the high-technology sectors of the economy and in service activities we are less and less willing to use people basically as machines. Even the degree of control that time and motion studies and the like gave over people disappeared. In a different context, ranged along a spectrum from the large, mass-production company to the small, entrepreneurial company

operating as an innovational team, the conflicts between the problem solvers and the implementers are being contained, if not eliminated. Indeed, a residual degree of tension is perhaps necessary to maintain vitality.

A third, and new, phase has now begun. Certainly in the UK a surprising number of people now talk of the need for leadership. Leadership is a word that went out of fashion after the war, perhaps because it implied the need for organisations like those used by the military where they seemed unlikely to work. Leadership is now coming back. I suggest that this is because, in a changing and perplexing environment, we accept that someone has to show the way. We are concerned with what, in his Stockton Lecture, Leavitt called pathfinding.

In a strategic leadership programme which we have designed at the Oxford Management Centre, we have concluded that the successful leader, whatever his field, requires drive and determination, intelligence and/or commonsense, an ability to communicate, and luck. Respect from his colleagues, earned from mastery of his own technical field, also helps. In the Oxford course, we emphasise the need for the leader to learn about him (or her) self, by developing basic skills like self-organisation, by working within his own temperament, by getting the best out of others, by developing efficiency, integrity and enthuasiasm in himself and others, and so on. Above all, we see leadership today as requiring an ability to motivate teams of people and make them effective. This is especially true in high-technology activities where those concerned will often be highly trained, at least in technical subjects where, in many ways, the high-technology team is one of equals. The leader today cannot be isolated from his team.

Leadership today requires the formulation and implementation of effective strategy, with much more emphasis than before on the need to design organisations which will work effectively in a changing world. Leaders must understand, more than perhaps they needed to do in the past, issues like organisational behaviour and organisational design.

I would therefore contend that the business schools now have a good deal to teach us about designing and leading effective businesses, within which decisions can be taken logically and implemented satisfactorily by

blending the qualities of the problem solver and the implementer. Increasingly, I believe, these qualities will be blended through those of the leader - the pathfinder.

I have now laid the groundwork required to answer my self-imposed question: is science manageable?

First, the business schools. It has not been easy, even in the past two decades, for the business schools to work out what to do. They now face their biggest challenge - but correspondingly their biggest opportunity. British business schools have not yet really come to terms with production management. True, as I have already explained, manufacturing businesses perform a wide range of service activities, and the business schools have certainly made a contribution there. But the truth is that British business schools do not have a structure which is fully appropriate for helping manufacturing businesses. To the extent that they dealt with manufacturing at all, British business schools were concerned with the content and processes of manufacturing. The specific problem of manufacturing is how to manage a situation in order to make well-designed products more effectively. But manufacturing departments also have to be integrated effectively into the rest of the business. I have recently discussed these issues with a major multinational company. This has led me to take the view that while the problems of marketing, systems theory, personnel, organisational development, finance and accounting are all important, their teaching has not yet moved to a stage where it does enough to treat the manufacturing company as a coherent whole. Training for manufacturing industry must enable the business to manage this process of integration with increasing effectiveness.

For example, one result of the approach which the business schools have taken is that purchasing, which covers perhaps between 30–40% of total turnover in a manufacturing business, is virtually unrepresented in British business schools. There is only one chair of purchasing in the UK, and none in a major American business school.

Similarly, since business schools concentrate heavily on the service activities linked to manufacturing, this affects the way business schools look at the strategies of their own organisations. It is likely that

those who are expert in systems theory, finance, industrial relations and organisational development will play major roles in determining the strategy of a business school rather than those concerned with production. The multinational I consulted takes the view that this is "an upside-down reflection of the realities of manufacturing business .... manufacturing is only a part of British business but it is probably where our problems are most serious and where we are also historically least able". It is surely overstating the case to go on as they do to argue that the British seem to have a natural flair for banking, insurance and shop-keeping. Nevertheless, the grain of truth in even that comment is bigger than I would like.

Even at Manchester Business School (MBS), we failed to build up any real rapport rapport with what I shall describe as the metal bashers. We have been more successful with the process industries. For example, we worked with two major companies to develop our Operational Management Course which goes from strength to strength. But we found it much easier to develop relationships with the banks, especially the international banks.

The problem with the "metal bashers" was, I think, that we in the business schools saw their problems as intellectually uninteresting - though they were difficult enough in all conscience. They saw us as intellectually arrogant and bored by practical problems.

Our record in building up relations with manufacturing is not strong. Yet there is now a paradox. This is that the business schools may prove soon to appear weak even in what they now see as their area of greatest strength.

I refer again to my multinational business. It takes the view that the business schools are rapidly becoming out-of-date in systems ideas; that the impact of cheap computing power may be pushing the technology of information systems to a level which is beyond even the intellectual understanding of those in business schools. In their view, business schools are missing out as agencies in teaching information technology. Three years ago information technology might have been taught in a business school. Now, major companies claim that they have to go to a computer manufacturer or a private consultant instead. When it comes to understanding how to integrate manufacturing - and also science -

into the business and to identify the appropriate technology for its systems, there is a danger that British business schools will actually be left behind their clients.

We at MBS failed to understand the metal bashers, because we were intellectually arrogant. To the extent that we built up rapport with the process industries, we did so, roughly, as equals. So we did with the banks. I do not believe that business schools will find it easy to build up relationships with the high-technology industries in a situation where they will now frequently be intellectual inferiors.

This is the nature of the challenge, and perhaps it applies to science and technology as well. In the multinational I have been quoting, ten years ago one of their factory managers would not necessarily have been a graduate. Now, the job cannot be done unless the manager is a PhD. Perhaps it is <u>they</u> who are now becoming intellectually arrogant, but the high-technology industries are increasingly arguing that even those with engineering degrees are now insufficiently creative to deal with the attitudes, knowledge and skills required in systems management and systems engineering. The criticism is that instead of doing what is required, the universities invariably deal with facts, because facts can be treated in traditional ways.

Business schools and university engineering departments seem now to be under similar criticism. They are under criticism from the industries of the future, industries in which those engaged would argue that systems practice has raced ahead of systems theory.

Now for my punchline. Since both engineers and business schools are under criticism from the same source, they have a joint opportunity. Especially in universities like Manchester, I should like to see - and would strongly support - a determined effort. This would bring together business schools and science and technology faculties in a three-fold endeavour.

First, there should be research. If, as I am told is the case, modern systems are too expensive to duplicate in universities, then this will have to be a joint effort with high-technology industry. It will be better, not worse, for that.

I am, I suppose, talking here of basic research. The business school probably

has less place than with any of the other issues I shall discuss today. It really does seem to be a case, as was once said in another context, of having to cast one's bread upon the water hoping that some of it will come back buttered. Second, there is development with an even bigger challenge and opportunity. Again I would like to see collaboration between science and technology faculties in business schools. Again, I would like to see them collaborate with business. Whether or not we could replicate modern technological systems within universities, or indeed the management problems of science-based businesses, is beside the point. There is no need. Development and application can best be done on site, in collaboration with those who work there. Maybe we should begin in a small way. Maybe the best instrument is the teaching company scheme of the Science and Engineering Research Council, with which I hope my own Council will increasingly collaborate. I believe that business schools could make a major contribution here. We, in Manchester, have a long record of "action research", or "action learning". In technological development one is not dealing simply with physical phenomena. One is also dealing with people in organisations, and that is where the business schools have strength. There is enormous scope here for genuine collaboration both within the university, and between the university and business.

Third, such collaboration would link both back into research and forward into teaching. It would link back into research because good theory is the foundation of good practice. It would link forward into teaching, because teaching could then be based on genuine understanding of current practice and current problems. Indeed, I would go further. I hope that "action learning" will play as big a part in degrees in science and technology as it already does in the business schools' MBA programme. And teaching (learning) must be <u>genuinely</u> interdisciplinary.

We do not need to restrict ourselves to Manchester. I have done so this evening partly because I see Manchester as having as much potential for giving leadership in this direction as any other university. I have done so also because we are in Manchester. But I should like to see similar developments pursued elsewhere, not least in Oxford and London. Collaboration, perhaps between the London Business School or the London School of Economics and Imperial College must have potential.

Then there is Oxford. Admittedly, there are times when I am convinced that Oxford will make no major contribution to management education during this century. But I should like to be proved wrong, and am delighted to see that my colleague Michael Earl has recently established the Oxford Information Management Institute.
But this is only the beginning. Perhaps the best next step is to ensure increased collaboration between those who teach science and engineering and those who teach management. In Oxford, and I suspect in many other universities with the enhanced engineering degrees, there still seems to me insufficient collaboration in teaching. Perhaps the best way to move towards effective collaboration in teaching is through developments in research of the kind I have outlined.

In this context, then, my answer to my question - is science manageable? - is that it must be. These developments will not happen by themselves. We must have a vision. We must then manage the achievement of that vision with determination. I hope that what I have said today may provide a spark both to such vision and to such determination.

I now move on to even more difficult problems though, having listened to me, you may wonder if that is possible. As we move on to the national level, though, there is a problem of comprehension, of understanding, as well as one of management. We could spend a long time arguing over whether the research councils and the ABRC do, could, or should "manage" those who receive funds from them. I do not propose to do so on this occasion. What I do want to do is to point to the complexity of the problems with which the ABRC has to grapple, whether or not you apply the word management to what it does.

I suppose that the complexity - even the near-impossibility - of doing what we want to do at the national level is especially obvious to me as a newcomer. Even the field covered by my own Council - enormously smaller than that covered, for example, by both the SERC and the MRC - provides a daunting degree of complexity. How much greater is the complexity dealt with by the Advisory Board for the Research Councils, which covers all the areas of all the research councils. The basic problem of the ABRC is therefore how to comprehend (manage) extreme variety.

One can divide that complexity into three parts. First, there are facts. There are facts about the range of research topics covered by individual researchers and research institutions; there are facts about research methods; about people; about ideas, etc.

Second, there is complexity in the concepts which researchers use. Current discussion of science is greatly influenced by Thomas Kuhn's book The Structure of Scientific Revolutions.(4) Kuhn points to periods when we engage in what he calls "normal science". We then see theories not so much as to be tested as to be used in order to solve what our former Manchester colleague F R Jeavons would call puzzles. In these periods science operates within the framework of existing theory, which provides a powerful puzzle-solving tradition, and an effective set of tools and techniques for carrying out research. At times, however, there are "revolutions". Clearly, these occur relatively infrequently, but there are periods when what Kuhn calls new "paradigms" are developed. I have often been worried over the difficulty I have in defining a paradigm, but am somewhat consoled by F R Jeavons. As he points out, "an eager student has managed to distinguish no fewer than twenty-one slight variants!". Kuhn admits to "having lost control of the word". For Kuhn a paradigm is a coherent tradition of scientific research, such as Newtonian dynamics or wave optics.

During periods of revolution when paradigms are being developed, knowledge is increased through criticism. Good research means making bold conjectures and then ruthlessly criticising them, in an attempt to disprove them.

The ABRC, then, not only needs to know what is going on in normal science; it not only needs to know what is going on in current revolutions; perhaps most of all it needs to know where the new revolutions - the possibility of developing new paradigms - may lie. The complexity here is large, which is why I refer to complexity of concepts.

Third, there is the complexity of the organisations - research councils, research institutes, universities and individual researchers - with all the attendant problems of organisational behaviour in a linked set of organisations. I find it inconceivable that this range of facts, concepts

(4) University of Chicago Press, 2nd edition, 1970, p10

and institutions could be comprehended by any individual. The question is whether it could be comprehended by any group.

One problem, which I am sure many of you will have noticed already, is that the field covered by the ABRC is far from clearly distinct from that covered by ACARD - the Advisory Council for Applied Research and Development. Indeed, I sometimes wonder whether the division made between the fields covered by ABRC and ACARD is tenable, and even more whether it is useful.

Be that as it may, the role of the ABRC is to understand the fields covered by the research councils, and these cover the whole vast field of basic and applied research, and indeed much development too.

The most forcible conclusion I have drawn from my recent return to Whitehall is that most of the really difficult problems are essentially managerial problems. Certainly, a body like the ABRC has to manage itself and even if it does not manage the research councils, they must manage themselves. The research councils have to devise effective ways of allocating money to research centres, researchers and postgraduate students. One can point to the need for the ABRC to give autonomy to researchers, universities and - to a degree - the research councils themselves. One can then quibble over whether anyone is managing the system at all. To me these quibbles seem very much beside the point. So far as I am concerned, all these <u>are</u> managerial problems.

The original notion lying behind the establishment of the ABRC made it a unique body. It brings together representatives of a wide range of sectional interests together with able independents. One issue - which has perhaps not been sufficiently thought through - is whether it is appropriate that a body whose basic job is to advise on the allocation of money to the research councils should itself have the five research council chairmen as its members. Leaving that on one side, the ABRC is essentially a forum. I therefore doubt whether the complex problem that I have already identified - and which I hope you will allow me to describe as managerial - can be tackled by a forum. In my view, the ABRC needs to be more purposive than that. Harking back to what I said earlier, this requires, above all, relevant leadership. There is clearly a managerial job which has to be done in making the ABRC work well.

To do the job I would insist that a change in the ABRC's culture - in the climate of the ABRC's thinking - is also required. This task of managing "the ABRC" is not eased by the backgrounds of those who compose it. I think here, especially, of the way that businessmen and civil servants approach this kind of task.

Businessmen seem to me to find it especially difficult to recognise the complexity of management problems in the public sector. That is, I suspect, why businessmen often perform badly when brought in to tackle broad political issues - for example as ministers. On the other hand, they perform rather well when tackling specific problems, as Lord Rayner has done. Business management is difficult enough in all conscience but in business, perhaps, leadership can by itself overtake the complexity of the situation. The problems of business actually begin to look rather simple when compared with those of government. This is, of course, why solutions to governmental problems proposed by businessmen often seem naive.

With civil servants, the problem is different. If anything, their difficulty is precisely that they are not naive when they think about these issues. They would say: not only must what is done be fair; what is done must be seen to have been done in a way that ensures fairness; and that fairness must be demonstrable to ministers, to Parliament and to the public. As a result, solutions to problems which I would regard as managerially efficient are ruled out because they imply, if you like, a degree of dictatorship. In many cases, I suspect, allowing the Secretary of State for Education and Science to reach a decision by himself on issues on the field of science would be as effective as the complex and expensive procedures we actually follow. But it could not be defended in a democracy.

A further problem with the Civil Service is that the automatic reaction in Whitehall to the discovery of any problem seems to be to tackle it by establishing a committee. As I have myself once said,(5) the Whitehall problem is that there are too many clever people sitting round tables. When, as with the ABRC, one has

(5) Public Policy and Private Interests (1973) Hague, Mackenzie and Barker (London: Macmillan)

sitting round the table 25 or 30 clever people who rarely meet outside ABRC meetings the problem is compounded. Perhaps the ABRC should establish an operations room, with charts and other visual aids showing what is happening in the field covered by the ABRC so that its members could have a better understanding of what is going on. Perhaps we should go beyond that to an idea borrowed from a young man called Robert Bittlestone. At recent operational research society conferences Robert has organised what he calls meta-conferences. Those who attend the conferences have access to mini-computers. During breaks between sessions or in the evening they use these computers to discuss with each other how the conference is going; what they think about it; how it might be improved. In the end, perhaps this is how we shall improve communication between members of large committees - by communication through the computer between meetings. We should at least then know what each other was thinking, rather than having to interpret scowls or gestures from across the table.

I believe, then, that the ABRC needs to change, but I believe that its bureaucracy also needs to change. Conventional bureaucracies cannot, by definition, produce fundamental solutions. We somehow need to devise a learning bureaucracy, rather than an administering bureaucracy. We need Whitehall to develop a connected set of learning organisations. This would comprise the ABRC, the research councils, parts of the Department of Education and Science and indeed parts of other Whitehall departments.

Nor is this simply a matter of trying to improve the relationship between the Whitehall machine and science. There are wider questions about how the members of the ABRC should act in their role as scientists.

Science has a double responsibility here. First, as scientists we need to set a good example by devising an effective organisation - in this case the ABRC. Beyond this, the responsibility goes much wider. Just as the ABRC has a responsibility for the whole science community, so the ABRC needs to show that wider community that it is both necessary and possible to design organisations that work well. That means designing an organisation which can learn.

How could this be done? First, the ABRC needs to come to terms with the fact that its role is as difficult as it really is - that it has to deal with a very complex set of facts, concepts and organisations. Having

grasped the degree and nature of that complexity, the Board needs to consider the appropriateness of its own procedures.

In particular, it seems to me, proposals for using the customer/contractor relationships need to be evaluated in this light. When Lord Rothschild produced this principle he must, consciously or unconsciously, have been seeking to use it as a device to reduce the variety which those at the centre were called upon to manage. He saw them delegating part of that variety to the joint management of a customer and a contractor. If there are many fields where that relationship has not worked, that may may well be because we were trying to use it in inappropriate circumstances. In the market sector of an economy, the customer/contractor solution does work: that is because there the customer really is the customer. That may be why the device also appears to work in the defence field. But it was bound to be difficult, and perhaps proved impossibly difficult, for other departments to act as proxy customers. We need to come to terms with the issues that this raises as we decide where, whether and when to use the customer/contractor principle.

How then could we make better use of the resources devoted to the ABRC I would myself put this in terms of the need to devise some way of institutionalising creativity and innovation - to create what I have just described as an organisation that learns. I see several elements in this process. First, there are questions to do with, for example, the size, composition and modus operandi of the Board. Second, there is a need to develop, or more probably to bring in, people with appropriate backgrounds, training and disposition. Third, there is the need to go on to make desirable things happen.

To organise this process, I would myself establish a strategy unit. Its detailed role would need to be worked out by those with more experience than I have. But I would see its ethos as being to challenge orthodoxies, to promote learning within the ABRC and to ensure that change actually happens, because it is institutionalised in the strategy unit.

The unit would need to monitor what was going on in the relevant parts of the external environment and to evaluate their implication for research. This would obviously mean monitoring economic, technical, social and political developments both within the UK and outside. It would also mean

monitoring new ideas and practices which were being evolved in universities, research institutes and research councils.

The task would then be to ensure that these developments were taken into account so that the ABRC could trigger off creative and worthwhile activity, and could do so not merely within the research councils but within the wider scientific community.

One can see at once the kind of objection that will be raised against this proposal. First, "think-tanks" are not in fashion in Whitehall. My own belief is that part of the reason for this is that the "think-tanks" we know have been given too much of a separate existence. This is especially true of the CPRS - the Central Policy Review Staff - which was closed last year. I would therefore suggest the establishment only of a small strategy unit, briefed and actuated by the ABRC and reporting to it. In my own role as Chairman of the ESRC, I feel a similar need for advice to help us make good policy, and am taking steps to receive it. How much more, then, does the ABRC - with the vast field which is has to cover - need such help.

The second objection would be to the likely manning of such a strategy unit. The role of the strategy unit would be to provide a bureaucracy that <u>was</u> creative. This would mean bringing in new ideas, attitudes and indeed people both from outside the scientific establishment and, indeed, from outside the Civil Service. This would raise again some conventional objections to think-tanks. The problem is that there are few, if any, civil servants with the background and training required of members of such a unit. At least some of its members would have to come from outside the community of natural scientists and engineers - perhaps from economics and certainly from business schools. A third objection might be that my proposal would follow Professor Mason in his recent suggestion that it is important to "strengthen" the ABRC. I have suggested that to say this is rather like saying that Stockport County could always beat Manchester United if they were always allowed to play thirteen men against eleven. My worry about what Professor Mason says is that it seems to me to imply that, once strengthened, one would have a next-to-omniscient ABRC which could, despite all that I have said, manage extreme variety with reasonable success. Perhaps a multi-disciplinary team of the kind I am proposing could make a good fist at omniscience. But it could do so

only if it did not concentrate solely on developing a top-down view. It would need to encourage the formulation of alternative ideas in a much wider constituency. And it would need to listen to these ideas. It would certainly not succeed as a single cell of creativity and knowledge in an embattled and conservative system. It would need to tap sources of creativity wherever these were.

The final objection might be that such a strategy unit would be expensive to man. Perhaps it would but, given the size of the total science budget - around £550m - this might be money well spent.

I now tackle one final topic. Looking at what the ABRC does, a purely managerial "solution" would be much less elaborate than the one I am envisaging. A management scientist might not go so far as to suggest giving the Secretary of State the final say. But he might feel that there was some merit in the idea of replacing the ABRC with a very small committee, with a leading scientist as chairman, and with the heads of the research councils as its members. This committee could then divide up the science vote and report directly to the Secretary of State. They would be accountable to him both for the way that the whole science vote was used and for the way that the individual research councils were run.

The problem is that while this might appear managerially efficient it would not appear constitutionally acceptable. There is a permanent and inevitable tension in a democracy between managerial efficiency and constitutional propriety. It may be that, too often, we take constitutional propriety too seriously and spend more than we need. This is certainly an issue which needs debate, but such debate will almost always end by requiring a more elaborate organisation than a purely "managerial" solution would require. There is a price to be paid for Parliamentary accountability and democratic control. It is right that such a price should be paid. The important question is how much more we need to spend - to keep Parliament and the public happy - over and above what it would cost to achieve what a manager would regard as an efficient solution. For the price we pay - in money and in time "given" to public sector work - is high.

So, for example, we should have to debate the role of the peer group. All research councils devote a good deal both of expenditure and of expert time to the evaluation of research proposals, research programmes and research

institutions by "peers". Some would argue that a more dictatorial procedure - giving money "to the best people" - would cost much less! Others would defend the peer group system to the death, almost regardless of what it costs. There is a whole field here which needs debate, and rarely sees it.

How, then, do I answer the rhetorical question: Is science manageable? - at the national level. The answer must be: Probably not, in a strict sense, but we have to go on doing our best.

Let me, in conclusion, summarise my basic thesis. I have tried to show that many of the most important problems covered by the ABRC, the research councils and the universities are - as I would describe them - managerial. I therefore believe that we need much more collaboration within universities between social scientists, natural scientists and engineers if we are to tackle and solve these problems effectively. I also believe that we are at the beginning of a new phase of rapid technological development. Many of the most pressing problems for science and technology are therefore problems of applying new kinds of technology. So the collaboration which I urge within the universities needs to be extended outside - to bring in those in business. I have argued that whether or not existing arrangements for university/industry collaboration have been adequate, there is a genuine danger that they will cease to do so before the information revolution has gone much further. I similarly plead for a new look at the way in which Whitehall organises itself to tackle the problems of funding science.

Obviously, fostering successful collaboration within universities, between universities and business and between Whitehall and the science community is bound to be a long and difficult process. But we can at least resolve to begin.