

The Science Budget

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It has become very fashionable in these days to speak of a country's 'science policy' and most countries now have somewhere in the government structure a body, or bodies, which advise on the uses of science for the benefit of the community Ireland is no exception, the National Science Council's main function is 'to advise the Government on science and technology with particular reference to economic development'¹

The growing interest of governments in science and technology derives largely from a realisation that these constitute important ingredients in the process of economic growth and development Quantitative evidence for this view is slowly emerging from, for example, 'residual analyses' of economic growth² These studies suggest that when the contributions of the traditional inputs of land, labour and capital are accounted for a residual source of growth remains A major component of this residue appears to derive from the infusion of new technologies into the economy, technologies which in the last analysis result from advances in knowledge based on the results of research and development (R & D) OECD has played a significant role in promoting these concepts and bringing them to the attention of governments (see, for example, *Gaps in Technology, The Conditions of Success in Technological Innovation*)

Very recently, science policy has assumed another and very important dimension with the clearer realisation of the social, as distinct from economic, implications of the use of technology Society has become increasingly more conscious of potentially harmful environmental or social consequences of new technological developments—such as those associated, for example, with persistent pesticides, pollution and drugs Efforts must now be increasingly directed toward evaluating in advance the risks and hazards of technological advances, methods must be developed which will measure social cost as well as economic benefit Decisions based on such information must then be made by governments and people, incidentally, lower risks will mean higher costs for many products and services

Because of its all-pervasive nature, science policy is rather hard to define This definition³ is a useful starting point

A government's 'science policy' may be defined as the sum of legislative and executive measures taken to increase, organise and use the national scientific and technological potential, with the object of achieving the country's overall development aims and enhancing its position in the world

¹ Annual Report, *National Science Council*, p 7, 1968

² WHELAN, N *Administration* (Dublin), Vol 17, p. 65, 1969

³ *Science Policy and its Relation to National Development Planning, from The Application of Science and Technology to the Development of Asia-Basic data and considerations* UNESCO (Paris), 1968, pp 116-7

Thus, science policy ought to be concerned *inter alia* with the following

- the Government's structure for science policy making,
- the country's scientific community (i.e. numbers, training, etc.),
- the country's network of scientific and technological institutions,
- research and development programmes,
- the encouragement of the innovation process in industry, agriculture, health, etc.,
- the consequences (social, psychological, environmental, etc.) of the application of science and technology,

and, most importantly, in the context of this paper,

- the allocation of financial and human resources to national scientific activities (i.e. R & D and related activities)

Increased annual allocations of national funds to science and technology has been the pattern in most countries over the last two or three decades. Scientists are, however, being increasingly pressed to justify these rising levels of support. Professor Derek de Solla Price of Yale University put it like this ⁴

In the atomic and space era science is rapidly becoming far too important to be left to the scientists. Part of the reason for this is that scientists have displayed incredible ingenuity over the ages in furthering their self interests. From the times of Archimedes and Leonardo onwards, they have been able to demonstrate conclusively to any government that maximum support of every need of scientific work was essential for the military and economic security of the state. Unfortunately, the demands of scientists now begin to exceed the possibilities of support, the pinch being felt first in the largest and most developed countries. We, therefore, begin to have a problem of "over-developed countries" where one must somehow learn to say no to at least some of the reasonable demands of the scientific community.

Thus, one of the main concerns of a science policy is to establish priorities which will form a basis for a differential support system. A balance must be struck, for example, between overall expenditure on research on the one hand, and development on the other, between science teaching and the dissemination of technical information within the economy, between the level of support given to science within broad areas such as industry, agriculture, communications and health, and, within industry, to different sections. Another question of policy concerns the extent to which a country should concentrate on importing

⁴ DE SOLLA PRICE, D. J. 'Measuring the Size of Science' Lecture to the Israel Academy of Sciences & Humanities, February 1969

and adapting existing knowledge rather than adding to the store of knowledge through R & D

Lack of information makes it extremely difficult to make these necessary choices with any degree of certainty "The uncertainties of forecasting are, of course, very considerable although greater in some areas than in others. It is probably because they have seemed so formidable that so little official effort has been put into attempts to formulate any strategic directions of advance for science as a whole. If the only foundations available for such plans are merely unreliable guesses, is it not better to forget the whole subject and let science go its own sweet way? In a non-critical period of history, this might have been the path of wisdom. But can we seriously doubt that the decades till the end of this century will be a period, not of quiet gradual advance, but of really intense crisis in nearly all fields of social life?"⁵

It is important to reiterate the point that the words "science budget" do *not* mean exclusively a "research and development (R & D) budget". I use them in the sense of covering a much wider spectrum of technical and scientific activities, stretching (as will be seen later) from R & D to testing, to standardisation and to membership of international scientific organisations. It is necessary to give this warning, as anyone who has studied the literature on science policy very soon finds that much of what is written on this subject deals practically exclusively with science policy *as far as it relates to research and development*, and that it is very difficult to find published work dealing with the science policy aspects of related scientific activities.

The objectives of this paper, therefore, will be

- a) to attempt to define the science budget,
- b) to attempt to estimate this budget,
- c) to comment on the extent of the budget,
- d) to comment on the need for a science budget,
- e) to indicate some experience of the problem in other countries.

The activities that would ordinarily be covered by a "Science Budget" are as follows ⁶

(i) *Research and Experimental Development (R & D)*, divided into

(a) *Basic or fundamental research*

Original investigation undertaken in order to gain new scientific knowledge and understanding. It is not primarily directed towards any specific practical aim or application.

(b) *Applied research*

Original investigation undertaken in order to gain new scientific knowledge. It is directed primarily towards a specific practical aim or objective.

⁵ WADDINGTON, C. H. *Science Journal*, Vol. 5A, p. 107, October 1969.

⁶ *Proposed Standard Practice for Surveys of Research and Development*, OECD (Paris), 1970 (in press).

(c) *Experimental development*

The use of scientific knowledge in order to produce new or substantially improved materials, devices, products, processes or systems

(ii) *Scientific activities related to R & D, including*(a) *Scientific education*

Education and training of qualified manpower in science, engineering, medicine and agriculture in universities and specialised institutions of higher and post-secondary education

(b) *Scientific and technical information*

The specialised activities of collecting and coding, recording, classifying, disseminating and translating scientific and technical libraries, bibliographic services, patent services, official scientific, technical and information services and scientific conferences, except where conducted solely or primarily for the purpose of R & D support

(c) *General purpose technical data collection*

Undertaken generally by government agencies concerning the economic and social situation (censuses of population, etc) or concerning natural environment (routine, topographical mapping, geodetic, geophysical, geological, hydrological, oceanographic and meteorological surveying, as well as routine astronomical observations)

(d) *Testing and standardization*

Refers to the establishment of national standards, the calibration of secondary standards and non-routine testing and analysis (physical, biological, bacteriological, chemical, statistical) of materials, components, products, processes, soils, atmosphere, etc

(e) *Membership of international scientific and technical organisations*

Refers to contributions made to organisations such as technical agencies of the United Nations (FAO, WHO), OECD, etc

Comprehensive as the above list may appear it should be pointed out that there are other scientific and technical activities which might be considered worthy of inclusion, e g

computation and computer centres, museums, zoological gardens, quality control

However, in the present discussion, we shall confine ourselves to the activities outlined under (i) and (ii) above

Even within this limitation it is obvious that in our context the science budget covers a vast and scattered area of activities within those Departments and organisations whose moneys are voted by An Dáil,

details of which appear in the *Estimates for Public Services*. The significance of this wide spread of the activities covered by the science budget is referred to by Waddington⁵

Until a few years ago—and in some places even today—it was common to hear the argument that a country could afford a certain total sum for research, and that the problem of assessing priorities between fields was one of “cutting the cake”. With the realization that all action needs to be based on knowledge, arrived at by processes which can be called “research” in a broad sense, it has become clear that the idea of a definite sum allocated to science as a whole is quite inappropriate. Research permeates all aspects of governmental action, some more, some less thoroughly. There is no single “science cake” to be cut up and parcelled out.

Government Expenditure on Science in Ireland

(i) *R & D*

Probably the most detailed information available in regard to Government expenditure concerns R & D. Two surveys have already been completed in this country, the first relating to 1963(7) and the second to 1967(8). In 1967 expenditure on R & D in the Government sector was at least £3.17m. (This figure was compiled from information supplied by Government Departments and certain organisations wholly or mainly funded from Departmental Votes, e.g. research institutes. It could not have been easily and completely compiled from the *Estimates for Public Services*, due to the way in which information on research and science is presented in that publication.) Two years later, in 1969, it is likely that the amount spent on R & D in the Government sector was £4.5m.

(ii) *Scientific activities related to R & D*

The amount of precise information, especially on financial aspects of this category, which is readily available is very small. This statement should not be construed as a criticism of any person or organisation, it is simply a reflection on the system of Government accounting and budgeting which has grown up over the years.

a) *Scientific education*

From published statements it is possible to tell quite easily the total State Grant to the Universities. Thus, for the financial year ending March 31, 1970, the *Estimates for Public Services*⁷ lists Grants-in-aid to Universities, Colleges and Dublin Institute for Advanced Studies, amounting to approximately £8.1m. While it is possible to tell the grants

⁷ *Estimates for the Public Service, 1969-70*

for certain narrow aspects of scientific education (e.g., Dublin Dental Hospital, College of Pharmacy), the published current figures for the larger Colleges are block grants with no indication, except in the cases of Agriculture, Dairy Science and Veterinary Medicine of distribution between faculties, this being left to the discretion of the Colleges

Even less information is available in the *Estimates* about the financing of Colleges of Technology, this being contained in an omnibus heading "Annual Grants to Vocational Education Committees", which in 1969-70 were estimated to require £5 73m An Chomhairle Oiluna is concerned with training, especially at the sub-professional level, and some of this activity is directed towards training of a scientific or technical nature, in this case also the *Estimates* give only a global figure for the administration and general expenses of AnCo (approximately £0 96m in 1969-70)

It will be clear, therefore, that if we are to get a reasonably accurate figure of Government expenditure in the field of scientific and technical education much additional sifting will be called for on the part of Government Departments, other State agencies and the higher education sector

b) *Scientific and Technical Information*

If the expression "scientific and technical information" in the Government sector were confined to library and documentation services the problem of preparing a science budget for these activities might not be too difficult The figure for the grant-in-aid for the National Library is readily available although this figure covers all activities including scientific and technical information on scientific and technical libraries in the Government sector (e.g., Department of Agriculture and Fisheries, Meteorological Service, Patents Office Central Statistics Office, Local Government) research institutes (An Foras Taluntais, IIRS, etc), and certain other bodies (e.g., INPC) would probably be fairly readily available through direct inquiry

However, as will be seen from the definitions given earlier "scientific and technical information activities" are now considered to cover a far wider field than library and documentation services They may include technical and specialist advisory services, patent services, licenses, and "know-how" agreements, and technical consultants and advisers This list embraces activities carried on by a large number of bodies in the Government sector Thus technical (and specialist) advisory services are provided (*inter alia*) by IIRS, IDA, INPC, IAOS, BIM, Foras Taluntais, Foras Forbartha, Department of Agriculture and Fisheries and County Committees of Agriculture Obviously, much scientific and technical information activity is being provided by the Government sector, but there is very little data available in official publications concerning the cost of these activities However, such data must be collected if we are to have a useful science budget

c) *General purpose technical data collection*

There is much activity going on in this area also. It is scattered among several Government Departments and agencies, e.g. Geological Survey Office, Meteorological Service, Ordnance Survey, National Soil Survey (AFT), An Foras Forbartha, Army Air Corps (aerial photography), Department of Lands (Surveying and Mapping Branch), Forestry Branch, Land Project (Department of Agriculture and Fisheries), CSO, OPW (data on water flows) and several others. In some cases (e.g. Geological Survey Office, Ordnance Survey, and Meteorological Service) the *Estimates for Public Service* give figures which enable one to estimate expenditure on scientific activities. In other cases, however, this is not possible.

d) *Testing, Analysis and Standardisation*

Organisations operating in this area include the State Laboratory (Department of Finance), the various laboratories maintained by the Department of Agriculture and Fisheries (e.g. those concerned with dairy products and milk, seed testing, veterinary problems, etc.), the Weights and Measures Branch (Department of Industry and Commerce), vehicle and driver testing (Department of Local Government), and the large amount of analytical work performed in the research institutes. Apart from the State Laboratory, financial data on these testing and analytical laboratories and services are not readily available.

e) *International scientific organisations*

Contributions to international scientific and technical organisations by various Government Departments are well-documented in the *Estimates for Public Services*. Thus, in 1969-70 the contributions by Government Departments to the activities of international organisations which could reasonably be termed "scientific or technical" was of the order of £0.5m, having been £0.25m in 1963-64, and £0.37m in 1967-8. These figures do not include contributions by other organisations in the Government sector, such as research institutes.

Public Expenditure on Science in Ireland

Having listed the many difficulties inherent in any attempt at estimating the present Irish science budget, it might be instructive to attempt an estimate.

In 1963 Government expenditure on R & D was £2.54m and that on "Scientific activities related to R & D" (excluding scientific education, for which no figures were available) was £2.04m, giving a total of £4.58m.⁸

⁸ *Science and Irish Economic Development*, Vols I & II (pr 8975, 9093) 1966, Dublin, Government Publications Sales Office.

In 1967 the amount spent by the Government sector on R & D was at least £3 17m,⁹ and if certain R & D expenditure in the higher education sector are taken into account it was of the order of £3 9m⁹ (p 49). Between the two years, therefore, Government sector expenditure on R & D increased from £2 5 to approximately £3 9m. If the other scientific and technical activities increased at the same rate, which is most probable, they would have cost about £3 20m in 1967. It may be (very roughly) estimated that the cost of scientific and technical education (i.e. in science, engineering, medicine and agriculture) in the same year was £4 5m. These figures suggest that Government expenditure on "science" in 1967 was on the order of £11-12m. If one were to add certain other technical expenditure, e.g. cost of hospital and other laboratories maintained by local authorities, blood transfusion and X-ray services, technical assistance grants to industry, use of technical consultants, computer use by Government Departments, etc., the current level of Government expenditure on "science" could be on the order of £15m *per annum*.

The R & D Budget

While Government support for R & D in Ireland rose by about £1 36m between 1963 and 1967, and that contributed by industry doubled to £2 2m in the same period, the total still represented only slightly more than 0.5% of our GNP, it is unlikely that this percentage has increased significantly in the past two years. International comparisons suggest⁹ (p 44) that we are not making the same effort in this activity as most other countries with which we trade. In fact, on the basis of approximate R & D expenditure per head of population *per annum* we are ahead of only Yugoslavia and Greece of those fifteen listed in the N.S.C. Survey.⁹ Of those Norway is the country considered most comparable to Ireland and in 1967 she spent more than four times as much per head on R & D as we did.

And the Norwegians don't intend to stand still. They propose to increase the % GNP devoted to R & D (1.2 in 1967) to 1.5 in 1975. High targets for R & D expenditure are being set by most other Western countries also. Thus Austria was recently reported by its Finance Minister to be growing steadily toward the target expenditure of 1.5% of GNP on R & D by 1975. France and Germany both plan to rise from a current 2.3-2.4% GNP to 3% GNP for R & D by 1975. Asian countries should according to an UNESCO recommendation aim at expending 1% of their GNP on R & D by 1980—thus, let me remind you again, is twice our current figure.

In the Netherlands Government expenditure on R & D showed an average increase of 16% per annum between 1964 and 1969, in France

⁹ *Research and Development in Ireland 1967* (Diarmuid Murphy, ed), Dublin, Government Publications Sales Office, 1969.

and Germany the figure was about 18% *per annum*. These compare with an increase of about 14%, compound, in Ireland. Professor C. Freeman, Director of the Science Policy Unit at the University of Sussex, recently suggested that, for various reasons, it would be prudent for us to improve on that performance in future years.¹⁰

It is obvious that, while we cannot base our policy on international comparisons such as those I have just referred to, we must, I believe, note current trends elsewhere with concern. The increasingly large national commitments to R & D in other countries constitute part of their national programmes for economic and social development. Many of these countries will hopefully be partners of ours in the Common Market before too many years have passed. Thus, it would be remiss of the National Science Council if it did not advise the Government that it should aim at a rapid increase in the percentage GNP devoted to R & D, from the present 0.5-0.6 to a modest 1% by 1973 at the latest. To achieve this, R & D expenditure would need to rise at a rate of at least 15% *pa*, compound, as against a 4% rise in GNP. Assuming the GNP to be somewhat greater than £1,500m (at 1968 prices) by 1973, the total R & D budget would need to be over £15m by then, with Government expenditure accounting for about 50%, or £7.5m. (The actual expenditure would probably need to be higher to offset the increased cost of R & D due to the inevitable inflationary factor.) It should be noted that this rate of increase in our R & D expenditure for the next few years (in excess of 15% *pa* compound) is no greater than that which has been common in OECD countries during the past decade.

I realise that such expenditure must be justified in terms of detailed plans relating to our national economic and social objectives but, given the will, these plans could be formulated. Moreover, I believe the Government could provide a necessary incentive for their formulation, and could effectively mobilise the efforts of the scientific community in the broadest sense in a constructive and forward-looking way, by declaring its intention of achieving an overall 1% GNP expenditure on R & D by 1973.

There is of course no point in increasing the financial and human resources assigned to R & D if the economy does not have the capacity to take up and utilize the results of experimental research studies. In the short-term therefore steps must be taken to ensure, for example, that the numbers of technical managers employed by industry who are conscious of the value of innovation are greatly increased, that the R & D performed for the purpose of economic payoff is relevant to the likely marketing conditions of the mid-seventies, that the agriculture sector is increasingly capable of employing the new technical knowledge generated by research.

The Science Council is acutely aware of the need to assess and recommend priorities for this greatly increased expenditure on science.

¹⁰ FREEMAN, C. *Technology Ireland*, Vol 1, p 8, 1966

With the co-operation of many others both inside and outside the public service, the Council hopes to help select those areas of the economy which show real growth potential. We will advise that the great bulk of the additional R & D expenditure be directed to solving problems in these areas and that the money be spent in such a way as to promote as much as possible technological innovation. Such a sectoral, as distinct from institutional, approach to R & D is, I believe, more likely to benefit the economy in the long run.

Already three areas deserving of increased scientific activity—mineral resources, marine resources and food sciences—have been recommended by the Council to the Government and were adopted for incorporation in the Third Programme for Economic and Social Development. Expenditure devoted to mineral resources has increased considerably in recent years with the reorganisation and partial expansion of the Geological Survey Office, but an examination of the economic potential—and of the scale of the efforts made in other small European countries such as Sweden and Finland—suggests that our effort is still much too small. There seems to have been but a relatively small increase in the funds devoted to marine resources, for example, the assessment of the potential of the continental shelf around our coasts has received scant attention, although there seems to be a great deal of activity in this area by several international companies. In food science and technology our total R & D effort appears to have been about £0.6m in 1967, with perhaps another £2m spent on other aspects of food science and technology. When one considers that a large international food company can have an R & D budget of greater than £6m per annum, the small and fragmented nature of our own national efforts in this area become apparent.

At the risk of being repetitive I would like to emphasise again that an initiative from Government in the recognition of the importance of a strong infrastructure of science and technology would be most opportune at this time. The announcement that there would be a disproportionate increase in national expenditure on science and technology—subject to the early formulation of co-ordinated plans for the various important sectors of the economy—could provide a major impetus to a commitment by our scientists, technologists and managers to building up the increasingly science-based industry which will characterise this decade. The enthusiasm generated by such an approach to science by government is obvious to a visitor to such countries as Holland and Germany.

Is there need for an Irish "Science Budget"?

It might be argued that a current total expenditure of the order of £15m on "science" does not warrant the effort involved in preparing a separate science budget and indeed this might be so if the only considerations were financial. However, in recent years governments have found themselves more and more involved in policy decisions of a

scientific or technical nature. Science policy is becoming more equated with national development policy. This has been summed up by de Hemptinne of the Science Policy Division of UNESCO.³

If science policy planning is to be an efficient, coherent and significant part of Government operations, the various activities in such planning should form an integrated whole. In operational terms, science policy planning activities should include, at least, the following:

- 1 Quantitative estimation of resources (manpower and financial), to provide the knowledge of the *nation's scientific and technological potential, which is an essential prerequisite for further action*, (a) by assembling the statistical data essential for comprehending the flow of scientific and technological resources (finance, personnel, facilities, etc.), (b) setting up a system of national statistics relating to science and technology.
- 2 Processing and interpreting the data from (1), and in establishing the national science policy budget.
- 3 Setting national priorities in scientific and technological matters.
- 4 Pursuing the objectives set out above, and the evaluation of the results of R & D programmes and R & D-related activities.

The science budget, therefore, forms an essential part of the nation's scientific and technological potential.

The main advantage I see in a science budget is that it would be an instrument for achieving a co-ordinated policy towards national objectives. We have in Ireland—as in other countries—difficult problems of defining our objectives in various sectors, of persuading people to work towards these objectives, and of inflexibility of high institutional and departmental barriers. These problems cannot be solved overnight, but I believe that a commitment to a science budget could achieve a great deal. Moreover, it would highlight matters of science policy and would lead, as has happened in a number of continental countries, to extensive parliamentary debates on science and technology, thus leading to greater public awareness of their problems and prospects. The concept of a “science” budget is new and one that in most countries runs contrary to established government budgetary practices. This point has been well summed up in the OECD document *Reviews of National Science Policy—Belgium*.¹¹

There is no country in which it is easy to replace the traditional budget prepared on a departmental basis by a separate science budget. It involves revolutionary changes in traditional administrative practices and Government Departments are reluctant to accept the idea that a new Government agency, even an advisory

¹¹ *Reviews of National Science Policy—Belgium*, Paris, OECD, p. 31, 1966.

body such as the National Council for Science Policy should be able to pronounce on the advisability of items of expenditure. On the whole, the science policy authorities have succeeded in changing both procedures and mental attitudes. The (Belgian) science policy authorities consider that this change in traditional budget practice not only makes it easier for the Government to keep track of expenditure trends for scientific activities, but also provides valuable experience. *The interdepartmental nature of Government action in the field of science is clearly brought out.* Departments are not told what they should do—they are asked to state their intentions.

The last two sentences state additional powerful and cogent reasons for attempting a science budget. Government “science” activities have grown up over the years in a haphazard, *ad hoc*, way, R & D and other units being created in many cases to meet a sudden demand. A Science Budget, by focussing attention on a multiplicity of units, would act as a very strong incentive to their rationalisation. An area which suggests itself in this connection is the study of various aspects of water resources. An overall Science Budget should also induce Departments to examine their own “science” structure, programmes and expenditures critically in order to see that they fitted in as effectively as possible with overall national objectives.

Experience of Science Budgeting in other countries

National science budgeting of the type proposed in this paper is not so far widely practised. Apart from the Belgian example just quoted the only other countries for which definite information has been obtained are Canada and the USA. In Canada, regular science budgets have been prepared by the Dominion Bureau of Statistics for the past five years¹² covering the following scientific activities of the Federal Government: Research and development, Scientific data collection, Scientific information, Testing and standardisation, Scholarships and fellowships, Capital expenditures. Scientific and technical education is not included, as this is largely (although not entirely) the field of the provincial governments. The Canadian statistics on scientific expenditure are quite detailed showing total and current expenditures by Government Departments, and agencies within Departments, a breakdown of current expenditures by activity, e.g., R & D, testing and standardisation, etc., and by whom the activities were performed, namely Federal Government, industry, higher education, provincial governments and foreign.

In the USA the information published about expenditures on scientific activities by the Federal Government is somewhat more restricted, dealing only with Research, development and R & D plant, Scientific

¹² *Federal Government Expenditures on Scientific Activities*, 1969, Ottawa: The Queen's Printer.

and technical information, and General purpose scientific data¹³ However, as in the case of Canada, quite detailed information is published

The need for long-term planning in scientific work, particularly in R & D, is universally recognised The five-year plans recently prepared by IIRS and AFT were drafted in recognition of this, but they can only be evaluated fully in terms of a long-term national science budgetary approach The move toward Government budgeting on a four or five-year basis, subject to periodic review, will shortly allow a more realistic approach to be taken to overall science planning Thus, the time seems opportune for a start to be made on the exercise of drafting a national Science Budget The fact that it has not been done before should not deter us, rather we should grasp an unique opportunity of gaining experience in a new field The Irish endeavour in collecting information concerning expenditure on scientific activities related to R & D (the Lynch/OECD Report) have been referred to by Professor Freeman as "pioneering"¹⁴ I suggest we should continue the good work by assembling a Science Budget which will allow us to ask important, specific questions concerning all our Government-supported scientific activities The answers to such questions will allow, among other things a more realistic assessment of priorities, not only in R & D but among all our scientific activities It should help ensure that both our money and our manpower is put to the best scientific and national advantage in time reorganisation of the science policy-making machinery may also be shown to be necessary

During the next few years, however, we must as a country make a greater commitment to science by deciding to increase our R & D expenditure in specific areas by what to us, is a dramatic amount Failure to do so, resulting as it would in increasing dependence on imported technology could well undermine our national independence in time I would submit that an expression of Government confidence of the magnitude I have suggested could hardly fail to generate a major and realistic response from the scientists and technologists on whom the growth of our economy will increasingly depend

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Dr Diarmuid Murphy of the NSC Secretariat was particularly helpful in assembling much of the material presented in this paper

¹³ *Federal Funds for Research, Development and Other Scientific Activities*, Vol XIV, National Science Foundation, NSF 65-19, Washington, D C

¹⁴ *The Measurement of Scientific and Technological Activities* UNESCO, 1969

DISCUSSION

Prof P Lynch It is with diffidence that an Economist trespasses on the territory of a Professor of Biochemistry My excuse, however, is that Professor Ó hEochá in his paper has most successfully made some very effective sallies into the Economist's field I compliment him on his very courageous effort, following on the pioneering work of Dr Diarmuid Murphy in trying to compile a Science Budget It may be difficult, if not impossible, to quantify all the components of a Science Budget, but it was highly desirable that where measureable components could be identified they should be isolated

The lecture has shown that by international standards the current level of expenditure in Ireland was low and that especially in regard to Research and Development international comparisons would suggest that we were lagging behind the effort of countries with which we conduct most of our economic relations International comparisons may be misleading, but we can hardly be misled very far if we say that in 1967 Norway spent four times as much per head on Research and Development as did Ireland Again, it is hardly encouraging to be told that the Asian countries had been recommended by UNESCO to aim at spending 1% of their GNP on Research and Development by 1980 and that at present our expenditure in Ireland is less than half this figure

I agree with the lecturer that we cannot base our policy on international comparisons, nevertheless we must accept them as general guidelines, especially if we are to equip ourselves scientifically for membership of the Common Market Assuming a growth rate in the Irish economy of 4% per annum for the remaining years of this century, we should be able to double our GNP by the year two thousand This development must have far-reaching consequences There are limits to the increases which private and public consumption will require and this means that more will be available for such services as Education and Science If Education and Science are at once the cause and consequence of economic growth there should for the remainder of this century be increasing scope in Ireland for expenditure on both services For this reason I think that we could hope, over the next thirty years, to aim at spending considerably more than 1% of GNP on Science and the scope for expenditure on Education both on capital and current account was very considerable as well It is worth while, I feel, to point to some optimism in the long run at a time when financial restrictions on our ability to afford the educational expenditures we so urgently need were limiting our effort in the short run

Economic planning that did not include the planning of Science Policy made no sense It is only in recent years that there has been a recognition of the indispensable part that science must play in economic and social development The great classical economists, Adam Smith, Karl Marx and others, saw clearly the role of science in economic development though it must be said that in Britain most people had only a hazy vision of the contribution that science could make to technological

development Individuals, such as Hargreaves and others, were fully conscious of the advantages of scientific methods but, generally speaking, Britain made a late start and Germany quickly learned from Britain's mistakes, hence the immense role of the technical universities in Germany's industrial revolution

I suspect that much nonsense is being taught and written about the residual factor in economic growth and that it was a mistake to go to pedantic extremes in trying to quantify it Mr Kaldor was probably right when he called it "the co-efficient of ignorance", yet the fact remains that Julius Shiskin, Chief Economic Statistician to the US Census Bureau, demonstrated in his remarkable publication—"Long-Term Economic Growth"—which contains almost every imaginable statistic about the US economy over the past century, that the residual factor has been making an increasing contribution to the expansion of the American economy In 1930 the US expenditure on Research and Development was £60m In 1964 it was £6786m No doubt this 1964 figure includes a vast amount spent on space research, but nevertheless it is obvious that American expenditure on Research and Development has been increasing enormously Since the 1950s the US economy has been growing by over 4.7% per annum on average which is well above the historic average of 3.3% It is little wonder that Professor Samuelson has observed that the only limits of American productivity are set by the availability of skilled personnel

The need for increased expenditure on Science in Ireland makes it all the more necessary that the greatest care should be taken to identify those areas in which expenditure on Research and Development is likely to produce the most fruitful results Selection of priorities is essential if the critical minimum effort is to be made in each case Any unthinking or unselective expenditure on Research and Development would be to waste the money available in the Science Budget

Dr T Walsh It is a privilege to have the opportunity of seconding the vote of thanks to Professor Ó hEocha for his very stimulating and constructive paper

The adoption of systematic planning and programming in the economic development of this country dates back to the late fifties From about this time a recognition of the role of science in the achievement of national economic and social objectives began to emerge This role however, was not explicitly spelt out at that time Since then there have been many major developments and it is now perhaps opportune to critically assess our standing and progress in science in this country Professor Ó hEocha's paper is a major contribution in this direction

There are two major conclusions which one can draw from his paper firstly that there must be a greater commitment to science and secondly that a science budget, based on long term planning, must be established

I support these conclusions I would however add some reasons of my own to those of Professor Ó hEocha's Science is expensive It requires the commitment of resources on a large scale This scale is

constantly growing and as a consequence the public stake in science has escalated. Public expectation of science has grown correspondingly in recent years. The public has become more science conscious and increasingly demands a payoff. Science, as an investment in human intelligence and ingenuity, must be seen to pay and to provide a rate of return at least commensurable with investment in other sectors of the economy. In order to meet this requirement, we are inevitably faced with the problems of administration and management of science with the resultant emergence of the need for techniques of evaluation and of critical budgeting.

I realise that when one raises the question of management of science, a great many scientific eyebrows are usually raised. I feel this is very often due to a failure to understand what is meant by management in its application to science, especially to the R & D aspects of science. We all know that management theory generally defines management principles as involving three fundamental functions, i.e., planning, organising and controlling. These can be emotive words. Some of the purists see a conflict between research management and scientific freedom, and might regard it as restrictive on the research worker. Breck regards management, for instance, as the determination of objectives, the laying down of a broad policy for the achievement of these objectives and the translation of that policy into programmes for action. In essence this means that management is essentially concerned with determining the tasks to be done and seeing that these get done efficiently.

The method of application of these principles will depend largely on the subject matter. It is my experience that much of the reaction by scientists to the concept of management lies in the attitudes and methods adopted by research managers rather than with the underlying principles. It must be realised and accepted once and for all that there is a vast difference between the way in which management principles are applied in a research organisation and in an organisation where the work is of more routine and day to day nature. In research it is essentially a question of the ability of management to develop and maintain an environment which stimulates and encourages the generation of new ideas and new knowledge.

Against the background of a need for a science budget, we might perhaps consider briefly some of the components of research management as follows:

- (1) The establishment of a policy for science, against the background of national goals and objectives
- (2) Within the context of science policy, establishing the priority of various areas
- (3) The allocation of available resources to these areas
- (4) The allocation of resources among institutions and organisations
- (5) The formulation by these organisations of detailed research programmes and the mobilisation of resources and facilities required to implement these

The key to the efficient operation of this process lies in an effective evaluation mechanism. This mechanism must incorporate suitable criteria by which proposals can be assessed and evaluated. Evaluation procedures must, as far as I see it, be used in allocating funds to

- (1) different sectors of the economy
- (2) within a particular sector i.e. including research and development, extension, grant schemes, veterinary control, education, etc
- (3) different fields of research within a sector
- (4) different institutions and organisations
- (5) different programme areas of research by individual institutions and
- (6) different projects and activities in areas under (5)

The formulation of objectives and goals at all levels against which the various problems can be evaluated is of paramount importance in the evaluation mechanism. It is against the background of proposals which are designed to meet specific objectives and which have been fully evaluated, and the relative priorities established, that the science budget should then be drawn up. In all cases the budget is established to meet the requirements of the programme rather than vice versa. In our Organisation we have at all times adopted this approach.

At our stage of economic development, it is obvious that investment in applied research must largely be determined by the harmony of its objectives with national socio-economic goals. Frequently research will largely determine the formulation of new goals and provide information for the development of new programmes. This forward aspect of science must always be considered in the applications of modern techniques of budgeting and management. The fostering of scientific creativity is an over-riding consideration. Here we are faced with a serious problem as there is so little reliable knowledge of research in its modern public setting to guide us in this area. To organise and plan science without damaging the creativity of the individual demands great skill and an appreciation of the human and social problems of the unique work environment of the research organisation.

Good science budgeting should be conscious of the needs of different types of research activity. Fundamental research, for example, which basically is an investment in an exceptional individual, has a long-term time horizon. In applied research, on the other hand, where activity is oriented to a specific objective, time becomes a critical factor. Applied research generally must meet tight time schedules and this must be taken into account in establishing the science budget.

Professor Ó hEocha's paper has spelt out the need for a greater commitment to science and for an expansion of expenditure in support of science. It is gratifying to see some of the views which I expressed as far back as 1963, on the need for a science policy for our own country,

so explicitly dealt with by Professor Ó hEocha. In this connection I can only reiterate that we must take into account our own particular needs. As a small country, we have a special necessity to economise in the use of our resources as far as possible. Over economising would however be wasteful and a stop-go approach in the provision of funds for science is especially frustrating and frequently disruptive and quite useless.

However, the public must be convinced that such expenditure can be productive. The products of R & D are sometimes difficult to sell. Returns from investment in science are not always apparent or readily identifiable. Fortunately there is at the present time a growing public receptiveness to science. Its role in economic development is better understood and appreciated than ever before. In this context research management must continue to narrow the communication gap between the research worker and the administrator, between research worker and user and between the period when research results are generated and their application in practice. More and more the performance and value of research will be judged by the extent to which such results are used.

I think we must above all realise that research is competitive in far more than the academic area. The success of Irish exports will continue to be a function of the competitiveness of their scientific backing. Our science effort and standing become of the highest importance in relation to our contact with other countries. We have all seen the turn about in relation to the French attitude towards an enlarged EEC which the present strength of British scientific and technological effort has created. It is especially within the context of a free EEC economy that there is now an urgent necessity for a substantial increase in the investment in science. The question is not "can we afford this investment?", rather the real question is "can we afford not to invest?"

There is one point above all which arises from an objective assessment of the present position and that is the need to get more facts, in the context of the situation in this country, about the science of science and it is especially gratifying to see that some steps have been taken recently in this connection. One could name a host of questions which, unless they are answered through the necessary fact finding, will act as a brake on and barrier to the evolution of a satisfactory science policy for our country.

Dr R Johnston In supporting the vote of thanks I would like to take up critically the notion of the "residual". It is perhaps the fault of the scientists for not making known better the significance of their work, anyone familiar with the historical evolution of science and technology and their interaction with economic life takes it so much for granted that technological advance is the major engine of economic change that they underestimate the lack of understanding of this dynamic which seems to exist among the economists. We must welcome the fact that at last the importance of the "residual" as a reservoir of

human creativity is beginning to be appreciated and that enough evidence has accumulated from the analysis of the macro-statistics to prove to the satisfaction of the economists what every scientist and technologist imbibes with his mother's milk

I do not see the need for a Science Policy research unit. What we need is a structure within which a science policy can evolve, with the necessary information flowing freely across the boundaries. A university research unit in this field would be better engaged in studying the history of science and technology, with particular reference to small nations in general and Ireland in particular, from which a background of dynamics of the interaction of science and technology with social evolution could be developed and made available to students of science and economics. Such a unit would be an invaluable guide to present-day policy-formulators and it would be unlikely ever to exist anywhere outside a university.

I welcome Professor Ó hEochá's recognition of the possible need to re-organise the science policy-making machinery. I made my contribution to the discussions which occurred in the scientific community prior to the setting up of the National Science Council, both in the Institute of Physics and in the Operational Research Society. I was able to include a minority view in with the latter body's submission, the essence of this view was that science policy, up to the level of the actual allocation of resources, should be under the control of a body consisting of representatives nominated by the organisations of the people concerned, a Senate-type structure, with some weighted voting system to make possible a compromise between the interests of the small and large bodies. The International Federation of Operational Research Societies operates a voting system whereby each national society has a vote proportional to the square root of its membership, for example. Other people concerned are of course the producers (the universities) and the users (industry, the State and semi-state bodies). Such a structure, by bringing the politics of science out into the open would ensure that it was widely and passionately discussed by people with real interest and concern. Perhaps however we do not want this?

Dr R C Geary I had not intended to speak but the excellence of the paper and of the discussion so far has led me to change my mind, perhaps unwisely, for my remarks may be chaotic and, worse, irrelevant.

First the national science budget. For some years economists have been exerting pressure on governments to present their financial statements in usable economic form. Their representations in Ireland are bearing fruit as several tables in NIE indicate. National science budget data would fit into such a scheme. From our statistical experience with the Department of Finance and in the present atmosphere, I am convinced that organizations of scientists could obtain all the information they want from the Department. But they must know what they want.

I entirely agree with the lecturer that our expenditure on R & D must be greatly increased, convinced as I am that no other investment is more likely to yield more substantially in the economic sense. Yet, of its very

nature, scientific research is wasteful, as firms and organisations are well aware. Committees and societies can create an environment and obtain resources for a scientist, they cannot do his work, typically a mountain, for a molehill of useful yield, using the term "useful" in its widest sense of additions to pure knowledge as well as applications to improve the welfare of mankind in the short term and in the mundane sense. Government, asked for funds for scientific research, must be made to realize that this wastefulness is of the very essence. To get the best out of the researcher he must be allowed a great measure of freedom within his necessarily broadly defined task.

In a still small voice may I remind the National Science Council that certain practitioners in economics regard themselves as scientists. Are they catered for in the NSC? In my view the Council's interests should extend to all sectors of the economy, to subordinate personnel as well as scientists proper.