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Applications in government policy making

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The paper looks at the evolution of operational research in civil departments of the United Kingdom government against the growing realization in the post-war period of the value of numerate methods for the development of policy over a widening area of government activities. It discusses the thinking about such methods which lay behind the Plowden Report of 1961 and 'Control of public expenditure' and the Fulton Report of 1968 on 'The Civil Service'. It acknowledges the contribution made by the Joint Conference with industrial and university representatives at Nuffield College, Oxford, in 1969. It traces the establishment of new operational research groups in the Treasury and the larger departments. Accounts are given of certain of the larger interdepartmental studies, including pioneering work on aspects of transport. An outline is suggested of the future application of operational research in civil administration, and of the problems to be overcome in securing the greatest possible advantage from it.

Every time that I hear it, I marvel at the phrase 'decision making'. It offers itself for conjugation thus:

I decision-make

You decision-make

He, she or it (if we have a Committee) decision-makes.

It has taken twentieth-century man to invent it, as a description of a scientific mystery behind the closed doors of the Board Room, the Cabinet Room or the Kremlin.

Yet there is a simple English word for the same process. That word is 'to decide', which the Pocket Oxford Dictionary defines as 'to bring or come to a resolution to *do*, on or for or against *doing*...'

The Executive Secretary has advised me to begin with clear definitions of the terms to be employed. I do not propose, however, to offer you definitions of 'operational research' or 'systems analysis' on the Irish ground that if this audience were to start from there they would not be here; and I mean no disrespect in offering you as the definition of 'policy making' – bearing in mind what I have just said about 'decision making' – that it is the latter with knobs on.

My theme, therefore, is how operational research and systems analysis may help people in government to bring or come to resolutions on or for or against doing something.

These people actually have to decide what they will do. Their problem is very often the complexity of causes and effects which will be associated with anything done, or not done. Much intended help adds to the complexity. Alexander Pope put the cry from the heart of those in government very well when he wrote:

'Who shall decide, when doctors disagree,
And soundest casuists doubt, like you and me?'

(*Moral Essays*, Epistle 3, lines 1 and 2)

What I have to tell you is not of any personal discovery of mine, but of growing realization that the rigour of mathematical thought can help people in government to comprehend before they decide – and help them in many more ways and to a greater extent than they might expect. In trying to unfold this growing realization I shall be drawing selectively on experience within the whole Civil Service, and on the personal achievements of my colleagues within the Service who have been, or are, practitioners of operational research or experts in systems analysis, and of those outside the Service with whom they have worked or from whom they have learned. I owe a special debt to Peter Turner of the Civil Service Department and Treasury for his great and unstinted help in bringing the material together.

In speaking of ‘growing’ realization, I imply both that realization has been growing for quite a long time and that it has a long way to grow. It is, however, both fair and important to acknowledge at the beginning that the development of computers has greatly extended the possibility, within practical time limits, of exploring by modelling methods the complexities of apparent causes and effects which occur in much of the field of action with which government is concerned. For this reason much that has happened in recent years in the application of operational research could not have happened much earlier. On the other hand, the back of an envelope has always been, and will remain one of the most useful instruments of operational research. Whether we need a computer or the back of an envelope for the job in hand, the main form of question with which government needs help is ‘what would happen if...’.

ISSUES FOR OPERATIONAL RESEARCH IN GOVERNMENT

This is a question with which government is or ought to be greatly concerned. If it can be answered sufficiently well, it may lead to the capacity to decide which of many things that ‘would happen if...’ would be the best result. This in some sense is what good government is about, what good government decisions are and what good government policy is. The special contribution of operational research seems to me to be as representing rigorous effort to raise and answer questions in the form ‘what would happen if...’ where there is reasonable ground for expecting it to be worth posing that question, or several such questions related together.

The form of the question ‘what would happen if...’ will, however, leave listeners groping after its meaning unless it is elaborated: ‘If what?’ If several things: first, if the situation in which action (or inaction) is to be decided is as it is believed to be – or not; second, if there are, or are assumed, particular limits, for example of money or manpower, on the possibilities of action; third, if there are believed or assumed to be certain probable or inevitable consequences (e.g. a strike) of particular possible lines of action; fourth, if there are results of a particular kind which it is desired to achieve, for example, some reduction in the prospective average number of prisoners per cell. And so on. In short, ‘if’ stands for variables in the assumed situation and in the intended outcome of action; and in principle it looks as if variables in the real world and their significant relationships are suitable for expression as such in the form of a model.

But they may not be expressible as readily as all that. There may, for example, be little or no statistical evidence of the probable extent of a particular possible variation in the assumed situation; or nothing but professional or political judgement to specify the result, or alternative results, which it may be desired to achieve. In such situations, as indeed in most of his activity, the operational researcher will seek guidance from his colleagues, administrative or professional (or both) as the case may be, who are concerned directly with the problem which he is

trying to illuminate. He will seek to express in formal terms what he learns from them, without, however, accepting such constraints that his work will do no more than reflect prejudgements of theirs.

His colleagues, however, have a problem in recognizing when he may be able to help them. So far as I know, no one has yet attempted to publish an exhaustive statement of the criteria by which someone not expert in operational research can spot its opportunity.

These two difficulties, that of expressing in formal terms, without bias, variables selected on the advice of professional or administrative colleagues, and that which the non-expert faces in comprehending the potential value to him of the approach embodied in operational research, are difficulties in the path of predicting how widely the approach may be applied to government business.

In the face of my two difficulties, operational research has penetrated government business up to now on the basis of 'try and see'. The rest of this paper will mainly describe selectively where the Civil Service has tried, and what it has seen, by these methods; and we will try to draw some inferences.

ORIGINS OF OPERATIONAL RESEARCH IN CIVIL GOVERNMENT

The history is not a simple biography of operational research. It is rather like one imagines the beginning of agriculture to have been; seeds grew here and there and their fruit was good; and the seed of that fruit began to be planted systematically, and where the ground and the seed suited each other, the harvest came. The usual thumb-nail sketch of the history of operational research in government is that the seed flourished in defence before and during World War II, as indeed it did with the Blacketts and Zuckermans and Waddingtons cultivating it there and as it has done since in the good soil of West Byfleet; and that it was blown about after the war and took root in the civil departments. The truth, as I have been able to trace it, is not as simple as that.

In the first place, the roots in pre-war days went a little wider. They can be dug up, for example, in the concern of the Home Office with air-raid precautions, which developed later into guidance supporting our own air offensive and later still our defences in the days of the Cold War. Zuckerman appears on this stage too, and Bernal and Stradling and Bronowski.

EARLY POST-WAR DEVELOPMENTS

At the end of World War II a report of the Advisory Council on Scientific Policy recommended that since operational research had been so successful during the war, its use should be confirmed in peace-time by the appointment of scientific advisers to the major departments of Government.¹ It would be their task to promote the use of operational research and scientific methods generally in the solutions of the problems brought by peace. These appointments confirmed the existence of the group in the Home Office and one subsequently set up in the Board of Trade and as a result of this initiative, a group was set up in the Ministry of Works. The Board of Trade group joined the Department of Scientific and Industrial Research (D.S.I.R.) whose task, as we shall see, was to promote operational research in industry rather than government, but a civil aviation operational research group remained in the Board of Trade, and ultimately became the Operational Research Unit of the Civil Aviation Authority. But

progress was not impressive. Most of the leading exponents of wartime operational research had returned to their universities and original scientific disciplines.

The D.S.I.R. group began life in 1952 in response to the nobly intelligent concept of the Marshall Plan of economic aid from the United States.

The group set up the Industrial Operations Unit which was thus known by the reproachful but expectant initials of those words. It worked mainly through research and trade associations, with emphasis on appreciation courses and other means of education. The diversity of the subjects was astonishing. It included projects relating to the central heating industry, doctors' group practices, the production of concrete, economic planning of secondary schools, the baking industry, the timber and saw mill industry, the cotton industry, the hotel industry, the carpet industry, rubber, printing, bottling, quarries, the clothing industry, the blood transfusion service, and, as if all else had failed, the organization of cemeteries.

D.S.I.R. should have the credit for another initiative. The Royal Institute of Public Administration set up the Local Government Operational Research Unit in 1959, with a grant from D.S.I.R., to promote the use of operational research in local government. The Ministry of Housing and Local Government also received some help from this unit.

But in the 1950s such other operational research as was being done in the civil departments was mostly part of the work of assessment, statistics and economic groups carrying out their normal advisory rôles. We are still looking, therefore, for what could be recognized as a programme of operational research, or a concentrated effort in the civil sphere of government.

The beginnings of an upsurge in operational research occurred, however, in 1962 following recommendations of a Royal Commission on the Police Service.² They thought that there should be a central research facility to help police forces develop their methods and equipment, and this was formed under the general guidance of Tony Sargeant, the Chief Scientific Adviser to the Home Office, in 1963. Here, the posting of the senior staff applied experience of operational research in defence to peacetime operational situations with characteristics similar to those encountered in war. One of its most valuable and interesting results has been the design and installation of computer-based control rooms in major police forces, which bring together the technology of communications and information display, and the power of computers for information storage, reference and analysis.

The same train of thought has fed the thinking of the Home Office about fire, through the Scientific Advisory Branch. Economic study of the losses which fires cause and of fire casualties is in hand to guide legislation and publicity. A functional analysis of local authority expenditure on fire services, and the time spent by firemen and those concerned with preventing fires on their various main activities, is in hand to show what a fire service should consist of and how it should be organized. Conclusions on the number of appliances for a brigade area, and their best deployment, with the use of cost-effectiveness criteria, are being tested in a group of brigades; and they look good. And so on to development of models of fire growth and possible fire-fighting tactics, with the saving of life as the prize. The Home Office have tried operational research quite a lot, and are seeing quite a lot.

CONCERTED DEVELOPMENT IN CIVIL OPERATIONAL RESEARCH

But what of more concerted effort? Back again for this to the Plowden report on the Control of Public Expenditure³ which appeared in 1961. The first of its two main recommendations, that public expenditure should be surveyed over a period of years in relation to prospective national resources, need not detain us here: but I shall refer later to an important sequel. The second was that greater attention should be given to improvement of management throughout the public service, and to quantitative techniques in particular. Paragraph 53 of the report said:

‘In general we believe that there should be active consideration of the wider application of quantitative techniques both to policy and to management: there is no simple or straightforward method of strengthening Whitehall here, and there is an acute shortage of professional statisticians and other experts of this kind; nor is there any one specific type of professional work or of skill appropriate for all kinds of quantitative work. Experiment is likely to be necessary, and the civil departments will have to build up their own expertise just as the Service departments have done in operational research.’

Having immediately established the Plowden system of medium term planning and tackled the statistical problems which this involved, the Treasury went on in 1965 to introduce the nucleus of an operational research team into its advisory Organization and Methods Divisions. By 1968 this nucleus had grown to a full Division, operating alongside O.&M., under the direction of Ken James, who had previously been the Director of the Army Operational Research Establishment at West Byfleet, later to become the Defence Operational Analysis Establishment (D.O.A.E.). Several more of his colleagues had gained their experience in the world of defence. The Division set about establishing its relations with Departments, encouraging cooperation in studies which crossed departmental boundaries, giving or securing professional advice, and carrying out studies of its own, though not yet of great significance for policy in the civil world.

There followed almost immediately, in June 1968, the Fulton Report⁴ and the division of the Civil Service Department from the Treasury. Thus the new Operational Research Division found itself in the new Department. Among the many recommendations contained in the Fulton Report was further emphasis on the need to use numerical methods and modern management techniques in government. This led to a review of the extent to which such techniques were already in use and where they needed to be either introduced or reinforced.

In January 1969 Sir William Armstrong (now Lord Armstrong), then Head of the Civil Service and Permanent Secretary of the Civil Service Department, led a seminar at Nuffield College, Oxford, at which possible developments in this field were discussed by a galaxy of Ministers, officials, academics and practitioners.

The object was to clarify what operational research could do for government if more of it were done, where – if anywhere – it should be placed in government, and how it should be organized.

The papers presented at that seminar covered the subjects in vogue, operational analysis, cybernetics, econometrics, systems engineering, systems analysis, total systems analysis and so on. The D.O.A.E. contributed a paper which made the point that too often the work was *ad hoc*. Whether the question was posed by the Minister or arose in the course of the operational work of the Department, problems were usually of the moment, to be answered to a date-line. On the

other hand, the D.O.A.E. was concerned that each one of the studies it undertook added to the sum total of its detailed and structured understanding of defence, so that as time went on problems would be solved less and less in isolation and more and more in perspective with the total aim of defence. Increasingly operational research in defence, and in particular the work of the D.O.A.E., was becoming applied to aiding decisions on allocation of major resources between competing claims and formulating long-term strategy and policies. This process, involving decisions and interactions between political, military and scientific judgement, could be supported to an increasing extent by analytical methods which expressed numerically the merits of alternative choices, examined the sensitivity of input assumptions, and drew attention to the critical issues.

The conference recognized that the problems which operational research would be asked to solve in peacetime would on the whole be harder than those facing it in war. If you are trying to find out how to minimize the opportunities for successful attacks on shipping by enemy submarines, or to destroy those submarines in the largest possible numbers, the goal is clear and the test of success is plain. In peace, even in, say, the industrial world, the goals and tests of success may not be so straightforward. The primary problem may be the reduction of inventories so that the money tied up in current assets is reduced and the return on total assets is increased. But if the resilience to industrial action in factories that make components depends on higher inventories, then management may think it unwise to plan to reduce them drastically. The industrial world throws up, indeed, many problems in which several objectives have to be weighed together. But at least there is a leading objective of long-term profitability behind which the others can usually be seen in perspective.

In the civil sector of government, however, there is less probability that the goals will order themselves in this way. If there are objectives to be found, they are numerous, interacting and imprecise. They are likely themselves to be the subject of political debate.

Few I think at the Conference had any doubt that something should be done to extend the use of operational research and its like in government, but it was clear that the great variation in the needs and problems of the civil Departments made it difficult to make proposals in any general form. Nor had operational research experience in government outside defence yet extended far enough into thinking about policy to show very clearly the direction to take.

The end of this particular chapter (or was it the beginning of a new one?) was that a year after the Nuffield Conference Sir William Armstrong wrote formally to Permanent Secretaries of Departments and made the following recommendations:

- (a) Departments which already had small study groups should consider whether these could be integrated to provide a larger, more viable unit. Such a group should have close ties with the management services organization which should otherwise have an operational research group of its own;
- (b) Departments which had no study groups of mixed disciplines should review their organization to see whether one should be formed;
- (c) Those Departments which considered after review that it was not practicable to form a group of their own, should be able to continue to draw upon the Civil Service Department's operational research division to help with their problems;
- (d) Departments should form joint study groups *ad hoc* when problems arose which crossed departmental boundaries. The Civil Service Department's group should provide advice and help.

The Civil Service Department's own Operational Research Division was to be built up to support these recommendations.

RELATION TO CONTINUING DEPARTMENTAL PROBLEMS

As these first moves towards concerted application of operational research in the civil sector began, the scene was one of widespread individual applications and developments. I have already mentioned some of those of the Home Office, but they were extending also to prison security and consumer safety. The Ministry of Transport looked at the parking problems in cities; an independent enquiry team was concerned with the vexed problem of the siting of a third London airport; there were problems of the likely size and nature of air traffic; and many more.

But here and there among these studies, which were pointed to the problems of the day, were to be found studies of a different nature, which sought more general solutions which would be able to answer questions of tomorrow not yet posed.

The Department of Education and Science had embarked upon a model of the education system. The Forestry Commission was attempting a financial control model. The Ministry of Technology was building a computerized model of the energy sector of the economy.

The Civil Service Department had started studies in various fields of essentially on-going planning models concerned, for example, with pay structure and career planning. The logical interconnection of the Department's own problems was being investigated, and a planning and control model for management of a small department was being structured.

A notable contribution in Defence was a successful study completed by the D.O.A.E. on the strategic movement of forces needed to reinforce and redeploy in times of tension in which, against a background of some eight scenarios involving movement of forces from the United Kingdom into Europe and elsewhere, various mixes of ships, aircraft and stockpiles were considered and their whole life costs estimated.^{5, 6}

This study entailed the development by the D.O.A.E. of a massive linear programme and the assembly of a large data bank. It resulted in a classical exercise in operational research in which various mixes of transport could be compared, and the sensitivities of the many assumptions tested. It provided the policy staffs with a reliable numerical basis for making judgements. There was an incentive to adopt a central and systematic approach to this problem, because it cut across all three Services, and decisions were made which affected the Services in different ways. The text-book nature of the mathematical part of the work is noteworthy because it is very unusual – applications of the techniques of operational research which are taught in colleges are, I am assured, comparatively rare.

In the spring of 1970 the Department of Health and Social Security (D.H.S.S.) introduced an Operational Research unit for the first time. Its first task was to construct an on-going model for resource allocation across the whole of the health and social services resources. From the beginning it was seen as an adaptive model. One of the requirements was that it should be capable of being developed while at the same time it should help the Department to solve some of its major problems of allocation in the short term. The model has now been made and described in the *British Medical Bulletin*⁷. It is one means in the Department of making quantified comparisons where more than one possible solution to a problem needs to be considered.

The Inferred Worth Model is specifically concerned with the way in which the development of services for one group of clients for services competes with those for another client group because of constraints on the overall availability of resources. It was conceived as an attempt to look across the Department's interdependent activities in Health and Personal Social Services in order to make it easier to say quickly what would happen if different policies were followed. The model represents not only the aggregate resources for the health and personal social service but also the consequences for patients, in terms of how many patients receive care, in what form and what intensity, given changes in the total resources and their distribution. It does not attempt to settle policy decisions but only to illustrate their consequences, so that those who have to take the decisions can test successive assumptions. The model is now being used in D.H.S.S., alongside other techniques, as an aid to their national planning. It is also being used as an integral part of the planning by an area authority of the National Health Service within the financial resources allocated to it, on a formula which again rests partly on work of the D.H.S.S. operational research unit.

I am not going to attempt to discuss the methodology behind this modelling work, which has been published elsewhere. But it is worth noting that the methodology of the Inferred Worth Model has attracted considerable international attention. It was presented at the Moscow Conference sponsored jointly by the International Institute of Advanced Systems Analysis (I.I.A.S.A.) and the World Health Organization (W.H.O.), was accepted at the conference and included in the recommendations which that conference made to I.I.A.S.A. You may wish to know that the director of I.I.A.S.A., Dr Levien, who is with us today, has requested the cooperation of the British team, and we are considering whether the project leader of the British team should not join I.I.A.S.A. for a period in order to contribute to and to learn from the international setting.

One can see in work of this kind the advent of a new dimension to the work of operational research in the civil sector of government. This has begun to emerge from an era of *ad hoc* studies. The on-going generalized model is beginning to appear which is able to give continuing advice to the decision maker.

There is another aspect of this. The human mind is well able to recognize human needs, goals, fears and prejudices, all of which should be (and, I think, generally are) taken into account by senior civil servants and politicians before coming to any particular decision. It is also remarkable in its ability to understand complexity, with an effort, and it can build models of the reality it perceives.

Where the human mind is very bad, however, is in tracing over a period the interplay of the many factors in these models to see what the very structure it has built will amount to when its components have interacted for some time. But a great number of our decisions require us to do just this. This is where I believe that operational research may eventually make its greatest contribution, especially in conjunction with computers with their enormous capacity for memorizing and analysing data.

I shall now turn to an example of a specific departmental issue – formulating a subsidy policy for the bus industry.

Subsidies were almost non-existent a decade ago, but over the past few years have grown substantially. The cost of running the bus industry in 1975–6 was about £1100M, some £250M of which was derived from a variety of grants and subsidies from central and local government.

We have all seen buses with more and more empty seats. Use of buses has been falling steadily for twenty years or more. It now stands at only half the level reached when bus travel was at its peak in the early 1950s. The main reasons for the decline are increasing car ownership (every new car results in 300 fewer bus journeys each year), higher fares and a poorer level of service (as operators attempt to make ends meet). Analysis of these trends and studies of actual fares and changes in the levels of service, has produced numerical values for the main parameters affecting bus patronage, which have been used in models set up to explore the likely economic consequences of various subsidy policies.

One such model, calibrated against survey data, investigated a zero fare scheme for London and includes underground as well as bus travel. This indicated that by reducing boarding times, by eliminating ticket handling and by making one-man operation more widespread a free-fares policy could produce community benefits through savings in time and operational costs. These, however, are not the only consequences of zero fares; experiments indicate that there is a good deal of switching from walking to public transport if travel is free, but very little switching from cars; simulation indicates that there might well be a shift of homes from the centres of cities to the suburbs, bringing escalating costs, while efficiency is likely to tend to fall off when normal commercial yardsticks are applied less vigorously. It might be argued that any increase in the cost to the public purse could be regarded as a transfer payment. But the public expenditure would be so substantial as to raise important questions at national level about the allocation of resources. On the question of who pays and who benefits, free travel may not necessarily be progressive: it depends on the way the money is raised.

There we have a problem illuminated, if not identified, for the policy maker, who is my Secretary of State and my Department. The problem is already exposed for public discussion in the Department's Consultation Document of last March⁸.

RELATION TO CONTINUING INTER-DEPARTMENTAL PROBLEMS

Let us turn next to a much wider group of problems where, for the first time in this account, the main spring of the development of operational research was not exclusively the need of a Department to discharge its own responsibilities: for example, the problem which Departments share with the Treasury in the planning and control of public expenditure. As I said earlier the development of the system of information and the ministerial and, eventually, parliamentary processes of control since the end of the 1950s has been fully described elsewhere. The particular point of interest here is that the sources of information which were used were those which were already available at the time. The quality of the information had to be improved if it was to sustain the weight which was placed upon it by the new arrangements. During this time as Permanent Secretary of the Treasury Sir William Armstrong entrusted to Mr Wynne Godley, in 1967, the task of analysing particular respects in which existing information was deficient and securing the necessary improvement. Again I can only illustrate the approach by examples of this work.

Finer accuracy was required in forecasting the big capital programmes controlled by government. Moreover, it had to be possible to understand, for example, what would really be happening on the ground from sources of information which expressed only the passage of money payments. The first task, therefore, was to construct a time series of information about all the

projects making up a programme over a run of years, from the earliest conception that there should be such projects through their planning, design, tendering processes, their construction, measurement of work done, payment for work in progress, and the final conclusion of all financial transactions relating to them. Mr Godley suggested systems for recording and analysing this information in relation to the school building programme of local authorities, and the road building programme of the central government. It was a task which would have been impracticable without computers of the capacity available at the time.

But this foundation of information was only the first step. Unfortunately, the course of the British economy has not allowed a programme such as the roads programme to be settled five or ten years ahead and left to proceed in accordance with those decisions unchanged. On the contrary, those concerned with managing the programme have had to do so in rapidly changing circumstances, not only of uncertainty but of successive decisions to make massive reductions in planned expenditure. In such a situation, that 'what would happen if...' question comes up over and over again. Management of the roads programme has rested heavily on mathematical modelling designed to enable the managers of the programme both to see the practical implications of changes in their plans on the scale required, and also to wring the maximum advantage from the programme as reduced. The Treasury and the Department agreed that the feasibility of mathematical modelling for these purposes in relation to the road programme should be examined, and a team including operational researchers was appointed in the Department who carried out a feasibility study in 1970. This resulted in recommendations for a computerized system with three main components – an accounting system for the roads vote, a data base of information on road schemes, and mathematical forecasting and planning models to assist the financial control function. The whole system has become operational during the last two or three years, but of course it has to be continually developed. The particular contribution of operational research has been the models which systematically use data on past schemes and performance to provide more accurate forecasts of expenditure, and which use explicit methods of adjusting the start dates of road schemes so that resulting expenditure lies within the ceiling on expenditure determined by the Cabinet.⁹

The operational researchers who were appointed to the Department in 1970 went on secondment from the Civil Service Department's team. Their contribution on the highways programme, however, was an opportunity created for them in part by the Treasury, and the Treasury suggested that similar opportunities should be sought with other Departments. To make this more straightforward, the Treasury and the Civil Service Department agreed that several of the members of the operational research unit in the Civil Service Department should be placed in the Treasury, so that they could help in two ways. First, when the Treasury felt that there was a possibility of improving by operational research methods the quality, for example, of the forecasting of some programme of expenditure undertaken by a Department, they could introduce a competent practitioner to the Department where such a man was not already available. This has been successfully achieved in several cases, and valuable work has been done in the Department of Industry, in conjunction with the Department's own Operational Research Group, on forecasting and control of expenditure on Regional Selective Assistance under the Industry Act 1972 (which is being carried on and expanded by the group there as part of a large and varied programme of work); on capital grant schemes for farms under the Ministry of Agriculture, Fisheries and Food; on re-financing of export credits under the Exports Credits Guarantee Department; and on legal aid administered by the Law Society.¹⁰

The Treasury itself has made use of the operational research team at their disposal in order to devise an improved model for forecasting the complex flow of payments of debt interest in the public sector.

RELATION TO LOCAL GOVERNMENT EXPENDITURE

A further development of this kind of work occurred in 1974. Roughly two thirds of all the current expenditure of local authorities is defrayed from the Rate Support Grant which is paid and distributed by the central government. In annual negotiations between the central government and the associations of local authorities, forecasts are made of expenditure on each of the various individual services which local authorities administer. Since 1971 these forecasts have been provided by joint groups of officials from central and local government. But with the increasing size of local authorities' expenditure in relation to total public expenditure and national resources, and increasing concern to forecast it accurately in changing circumstances and under the influence of tightening constraints, even services previously regarded as very much at the discretion of local authorities now require to be more accurately quantified. The quantification has to take account of all the varying influences on expenditure, such as the flow of net new current expenditure from completion of capital works, changes in the responsibilities of local authorities, trends in demand for facilities and levels of charges. Following an initial study by the Operational Research Unit in the Treasury their colleagues in the D.O.E. prepared a model covering local authorities' expenditure on recreation, parks and baths which has been used this year in a report to the Consultative Council in which the negotiations of Rate Support Grant, amongst other things, are now conducted between the central government and representatives of the local authorities for England and Wales. Design is continuing of models for other services for which rigorous forecasting procedures have not previously existed. Improved forecasting is one condition of better decisions on public expenditure and of improved control.

If every one of our major expenditure programmes was covered by these sorts of facility, we should have a more effective system of planning and control. But it takes time to design and build these systems and to introduce them into the day-to-day business of Departments. Although the specialist effort at any one time on any one system may be small, the number of systems that can be given this attention is still limited. Hence I think that the possibility of applying fairly standardized models to expenditure programmes (which smacks rather of 'looking for problems to fit our solution') is nevertheless something that should be examined very carefully if we are to get the sort of improvement we are looking for.

RELATION TO CENTRAL GOVERNMENT EXPENDITURE

So far I have been talking about financial processes in Departments, but it is implicit in everything I have said that the Treasury and the Civil Service Department also need to be able to monitor what is going on so that they can assess the room for manoeuvre, to respond to the changing priorities of government, and the economic pressures which require changes of policy.

To monitor, we need information continuously, or, in the jargon, we need management information systems.

In the financial field, the largely virtuous system of delegating responsibility to individual Departments of State, with the Treasury holding the reins at the centre, led to a proliferation of accounting and financial planning systems (and, if we are not careful, future computer-based

systems) which were not compatible with each other and might not readily yield as much standardized information to the centre as we might need in the future. At the centre, too, we needed to take account of the developing powers of computers to give us a quicker reaction to events and a more informed look into the future. It seemed appropriate for the operational research people to develop these systems for us because the financial planning models they will be developing in Departments and at the centre will have common needs for information and will be very much easier to build and more effective if they can be based upon a common system.

As with so much other operational research their study of central financial information needs and flows was multi-disciplinary, and leant heavily on management accountants and computer systems analysts. Administrators were also involved. In exchange, once the recommendations for new types of information and a new system to deal with it had been accepted, responsibility for setting it up was passed over to an administratively based team, but this time specialists from the old team are assisting them.

I must not give the impression that the result of this central study has been to place a strait-jacket around the accounting and financial planning systems in Departments. Rather it has defined more precisely the requirements placed on those Departments from the centre. It has also highlighted some functions which for some small departments might be done more economically at a central point. Finally, it clarifies the relation between the various financial planning systems which have grown up over time in the Civil Service, and which all have their special uses, but which require translation as if from one language to another.

RELATION TO WORLD PROBLEMS

Let us now turn to a wider canvas still. As many of you know, attempts have been made to apply the methods of operational research to the widest possible canvas, namely that of world problems. The concept of constructing models of the future state of the world, including the routes that lead from the present to those states, was introduced as a matter of quantitative technique by Professor Forrester in 1971. Forrester's pupil, Meadows, and his research team achieved prominence with the publication of *Limits to growth* in 1972.¹¹ 1972 was also the year of the Stockholm Conference on the Environment. One of the responses by the United Kingdom to that conference, and to the attempts at modelling states of the world, was the establishment of the Systems Analysis Research Unit (S.A.R.U.) in the Department of the Environment. This unit, working with other Departments, still has the brief to examine and report on models like that which was published in *Limits to growth*. It is also charged with the task of assessing the usefulness of such modelling methods as contributions to devising strategies for national and international political action to anticipate and to handle world problems.

There is certainly widespread disquiet about the possible future states of the world. World supplies of oil, world stocks of grain, world prices of raw materials, and so on have become common terms. Periods of decades are now thought necessary and right for governmental action, nationally and internationally. We speak of 'the energy gap in the 1990s'. Can this kind of thinking be fully and coherently formulated so as to give the nations, individually and collectively, the best possible opportunity to handle these world problems when they arrive or as their seeds are sown?

Although I have posed that question, I do not intend to offer a definitive answer to it. It seems to me that we owe a great deal to pioneers such as Forrester and Meadows who have

attempted modelling on a world scale, but that it would not be surprising if conclusions which may be suggested by work at their level of generalization were found to be apparently inconsistent with conclusions suggested by modelling of more limited prospective situations. This indeed seems to have happened already. For example, for the World Food Conference in 1975, S.A.R.U. examined possible future levels of food consumption and production in India, Bangladesh and Pakistan which represent a significant part – probably the gravest part – of the problem of adequacy of future food supplies in the world. The model which they devised for this study was presented to a symposium of the International Institute of Applied Systems Analysis. The importance of the model is that it suggests that doom of the sort forecast by Forrester and Meadows, rising from scarcity of raw materials, should be regarded as improbable. We have reason, therefore, by virtue of the work done so far, not to be stampeded into trying for a world strategy of ‘no growth’. I do not suggest that the debate is thereby disposed of. I suggest only that it is likely to be worthwhile to continue to try to conduct the debate with the assistance of rigorous systems analysis, not taking too long about it. In a paper which the Cabinet Office published this year entitled *Future world trends*¹³ one of the concluding paragraphs has this to say:

‘Mathematical models will play an increasingly important part in the study of future world trends, particularly in the investigation of the inter-relationships of the subject areas discussed. The broad conclusions of separate more recent modelling studies have tended to converge, especially in pointing up the problems of distribution rather than global physical limitations. An all-inclusive world model to answer our questions is an inviting prospect, but more narrowly based exercises aimed at specific issues can be useful aids to policy making.’

CONCLUSIONS

I said that I would offer some generalizations concerning the circumstances in which, *prima facie*, it may reasonably be expected that there will be a profitable opportunity to apply operational research or systems analysis to government business. This, in conclusion, I now do. The points to be made are all in qualification of the underlying question ‘what would happen if ...’. I suggest that we should look for that question in combination with one or more of the following situations:

- there are complex issues of allocation of money, manpower, building, training places or other resources;
- there are complex interactions between different parts of a system;
- there is uncertainty embedded in the structure and nature of the problem itself.

It will not escape your notice that the emphasis in this list is on the practical consequences of policies. There seems to me to be a very great deal of work to be done on such practical questions, leaving aside the no doubt more interesting and philosophical questions about the aims of government and how they can be reconciled. In case you misunderstand me, I am not saying that operational research has not been or cannot be applied to these questions, nor that its help would not be valuable. But access to them will usually be gained by showing a mastery of the practical consequences of policy, as a first step to better decisions.

From the practical work that we have seen in government, I can now offer you four conclusions.

First, the vast majority of decisions made in government belong to continuous and established (but not immutable) processes. The most effective operational research models will be woven into the fabric of these processes, so that they are used in the normal course of events.

Second, although many of the situations which I have suggested are suitable for operational research are complex ones, it is perhaps paradoxically essential to keep the models as simple as possible. New and more elegant ways of deciding can be introduced later, when specialists and non-specialists understand each other thoroughly.

Third, be prepared for model building to be a long process. The first model built will almost certainly need adaptation to changing circumstances and quite possibly to the manager's changing understanding of what it can do for him. Continuous development and support is necessary.

Last, operational research managers should be prepared to leave their bright young people behind to help to develop their models and indeed to assist in their everyday use. Although this may place a burden on recruiting, it will in the long run provide the exchange of experience that both sides need.

One final word. Except by chance, a decision will only be a wise and conscientious one if it is taken by wise and conscientious people. So back to Pope:

‘Like doctors, thus, when much dispute is passed,

We find our tenets just the same at last.’

(*Moral Essays*, Epistle 3, lines 15 and 16)

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