Operations Research: Some Experimental Applications

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It was in the late 1930s that the Royal Air Force, while experimenting with new radar stations, made the revolutionary discovery that the scientific placing of radar stations was a problem quite distinct from the technological one of making individual stations work reliably. What was even more revolutionary was the choice of leading physical and biological scientists to solve the problem. This use of the scientific method of enquiry to solve an operational *as opposed to a* theoretical *problem came to be known as Operational Research.*

In view of the circumstances of its origin and growth, OR has come to be seen as merely a way of tackling problems by breaking them into smaller problems to make them analytically tractable; the larger institutional causes of these problems are considered outside the ken of OR.

The present paper questions these assumptions and proposes some alternative applications of OR.

WHATEVER might be the confusion regarding the role of Operations Research (OR) today, its origin can be traced with some exactness. It was in the late 1930s that the Royal Air Force, while experimenting with new radar stations and faced with the problem of locating individual stations in such a way as to provide the most effective early warning shield against German bomber attacks,[1] made the revolutionary discovery that the scientific placing of radar stations was a problem quite distinct from the technological one of making individual stations work reliably. That is, the problem was to design a system whose elements consisted not only of the stations, but of their relationships (in terms of relative position) which would best protect them against an opposing system of attack (in terms of enemy bombers). The element that was revolutionary was the choice of a group of leading physical and biological scientists to solve the problem. This use of the scientific method of enquiry, which was common to all the 'natural' sciences, to solve an *operational* as opposed to a *theoretical* problem came to be known as 'Operational Research'.[2]

Ackoff has dated the beginning of the 'systems age' to roughly the time OR work began;[3] and it is interesting to investigate the possible causes for this change in the mode of thinking.[4] One of the objective factors that appears of some importance is that both OR and the Keynesian method of analysing problems in the economic sphere appeared first in England.[5] By the 1930s, it was clear that England was no longer the dominant capitalist power. This realisation might have been ignored to a certain extent by Germany's eclipse after the First World War, but after Hitler's invasion of the Rhineland in 1936, a new trial of strength seemed probable. The conventional method of settling such trials is similar to the control procedure described by Ross Ashby as the basis of football or other two-team games.[6] For a long period after the scientific possibilities of improving defensive tactics had existed in embryonic form, subjective awareness of these had not crystallised even in Britain which was in many ways the most advanced country scientifically. The reason was that British economic and political predominance made the wasteful effects of inefficient procedures, whether in war or elsewhere, of little consequence. But the rise of German military power, in particular air power, made a football game type of one-for-one defensive strategy more and more difficult. Thus proposals for developing a new form of control system dependent on science, not only in its use of advanced technology but also for organising a system within which these technological elements could be placed, became an urgent necessity.

Evidently, what was required was a method of modelling whereby the actual physical form of the elements was abstracted, so that they and the linkages between them which may have had no physical counterpart could be represented, either by a specially designed mathematical model, or by one drawn from the physical or biological sciences.[7] In the latter field, in particular, workers had long been used to working with linkages between physical elements which had no physical counterpart themselves (or for which none had been discovered upto that time).[8] Thus the specific novelty of the OR approach lay in the construction of a model to represent the system, and in many cases analogies were taken from biology and the natural sciences.

An important consequence of this approach was that many assumptions underlying the methods of the social sciences were not accepted. Precisely because of the naivety of social scientists towards the 'real world',[9] the hurdle of the distinction between the normative and the positive did not hold. If their investigations led them to the logical conclusion that the problem entrusted to them could only be solved by reference to a larger problem, they were much less influenced by the argument that as regards the larger problem, the existing situation was immutable. For instance, they might have found that institutions resting on private property were the fundamental cause for the lack of growth of a depressed geographic area in an otherwise booming economy,[10] while a diligent economist would have contented himself by recommending financial incentives for investments in those areas, and other useful and practical recommendations.

During wartime, of course, existing institutions are far less sacred, as long as changes brought about by studies serve the overriding imperatives of the war effort. But, in the meantime, the various OR groups had found that many of the problems they were faced with could be broken, or at that stage of the development of OR methods had to be broken, into smaller problems to make them analytically tractable, and for the solution of which standard methods could be developed.

In many ways this was a fateful de-

velopment in the evolution of OR.[11] After the war a great many of the originators of OR joined commercial organisations which were happy to have the services of these eminent investigators of operational problems, but were rather at a loss to know what to do with them. For instance if X had been employed by Division A of a company, its management would hardly take kindly to suggestions that problem Z could only be solved effectively by the amalgamation of Divisions A and B, or worse, by closing down Division A's operations because they were largely redundant. "Give us a practical solution taking account of the constraints within which we operate", they were told, and all their energies would be spent working out why stocks were piling up, or production coming down after the introduction of supposedly revolutionising machinery.[12] Many spectacular results were obtained this way, and in the process a fruitful new academic discipline arose. Eager research students in universities were given assignments to improve still further the mathematics of a technique, and to observe the results of variations in parameter values irrespective of any practical considerations.[13] It must however be said that a great deal of important work has been done in this way in improving algorithms for solving problems, so that computer-based solutions are more feasible; and that in essence there is no reason why academic work should not continue in these lines whether there is any immediate feedback on Operational Research or not.

It is quite another matter, however, when this activity in itself is defined to be OR, and MAs and MScs in OR to go into the world armed solely with a knowledge of mathematical techniques.[14] For what has happened is that an approach that set out to enquire into problems whose boundary was fixed only by the skill of the practitioner and the final equilibrium reached between him and his employer, has been diverted to the completely conservative technical approach of improving stock control, smoothing production bottlenecks and so on, with no room left for questioning the larger institutional causes of these very real technical problems. That is, apart from a few persons whose specific experience has led them to question the role of the OR worker, the bulk of the profession is happily advancing along the road to rational decision-making in industry and government, through the use of decision-making techniques.

In fact they may not all be that happy, for, particularly in public administration, there is little sympathy for this approach; but the point we wish to make is that the world view that present OR teaching inculcates is largely that of assuming that the techniques are the essence of real-life problems and that it is merely the stupidity of their audiences that prevents advocates of OR, in this sense, from achieving success. Equally dangerously, it produces a feeling of futility about all attempts to change existing situations, for in the training process, no element of the dynamics of social change has been included.[15] At the worst, it produces an attitude which was said to prevail in the Rand Corporation in the United States where much of the work on military problems was undertaken. "It's not our job to judge whether the United States should be fighting in Vietnam or not; that's a political/administrative decision and we can only advise on the best way of achieving targets set for us."[16]

Any attempts to define a distinct role for OR not confined to these techniques is complicated by the fact that many of the social sciences, having had to discard their positivist image in the wake of the acceptance of Keynesian interventionist policies, have taken over many techniques evolved in earlier OR studies. Thus econometrics is little more than the use of mathematical techniques applied to problems which neo-classical economies, which denies the need for prescriptive measures, cannot handle.[17] In other words, to the extent that the notion of planned advance, even if only in discrete segments of social life, has been accepted in capitalist countries, new branches of established disciplines have developed which carry over the segmented approach of their parent subjects aided by the OR methods they have adopted. It is then as difficult for practitioners of these arts to see that the problem (which OR sets out to tackle) is not necessarily one that lies within a discipline and can be tackled using the methods of that discipline as for adherents of the parent discipline.

Certainly it is true that after the operational problem has been viewed as a system of interconnected problems, these may be studied individually by the methods of existing disciplines; but the solution of the total problem is not the sum or any simple function of the solutions of the sub-problems. These latter have to be integrated in a manner which preserves the original structural relationships of the problem area. The originality of the best OR work is due precisely to the use of models which span discipline boundaries and thus enable the operational problem to be correctly defined. Of course, the question arises: what is the 'correct' way of defining a problem? In other words, is a system purely subjective? The most prominent of the advocates of what we will call Operational Research (OlR)[18] as opposed to Operations Research (OsR)[19] argue that this is so, and this marks them off clearly from Marxists.[20] For a Marxist, who presumably has a relatively clear conception of the broad direction of societal advance, the way the problem is defined is based on an objective understanding of the situation; and even if he is unable, because of the constraints of his situation, to avoid making options too narrow, the decision will be based on his morality which would in the final analysis define his approach to the problem. Thus to take a simple example where class consciousness clearly defines moral consciousness, a Marxist when asked to design a layout for a shop floor might take workers' convenience actively into account. The difference between this and an approach based on humanistic consideration or on the 'human relations'[21] school, is the consistency with which trends favourable to the working class movement are upheld within technical studies. A great deal of debate on 'OR for whom?' has really centred around this subject, though the general Marxist approach seems to be that it is impossible to continue in a situation where there is a fair likelihood of becoming involved in the design of precisely calculated anti-working class policies, whether within a production unit or in the capacity of a government administrator.[22]

The most ambitious attempt to bring about a relatively integrated system of

planning has been the PPB experiment in the US Department of Defence.[23] In fact PPB can be seen to be the result of the natural logic of OR work within single departments or other formally separated organisations where the analysis of the problem at hand has necessitated departmental reorganisation, or the development of methods of reconciling the integrated nature of forward planning, with the constraints posed by existing organisational frameworks. Subsequent experience and disillusionment with PPB applied on a macro-scale clearly shows the incompatibility of effective planning within a society characterised by private property, and upholding an apparently "pluralistic" ideology.[24]

What is of interest and makes these experiments worth studying is that evidently advanced capitalist societies are not only producing the social organisations suited to socialism but also developing methods of planning and organising within them, however much they may be limited by the logic of private property and the arbitrary divisions this produces within society, and in disciplines supposedly analysing it.[25]

Notes

1 'Thirtieth Anniversary of the use of the term Operational Research', *Operational Research Quarterly* (19, 2) pp 111-116. See also Stafford Beer, "Decision and Control", Wiley, London, 1960 pp 36-37.

2 Of course, this is not to deny the presence of various systems of philosophical analysis, e g, Positivism, dialectical materialism and so on. See also, Beer, *op cit*, pp 33-36.

3 Russell L Ackoff: Science in the Systems Age: Beyond IE, OR and MS, *Operations Research* (21, 3) pp 661-671. For a discussion of the distinction between Operational Research and Systems Analysis see R C Tomlinson, 'Decision Making, Operational Research and the Systems Approach', *Operational Research Quarterly*, Special Conference Issue, Volume 19, pp 1-4.

4 This is an important point, for we take as our basic thesis the development of the philosophic method as described in G Plekhanov "The Development of the Monist View of History", Progress, Moscow, 1972. If to this we add Lenin's Comment (admittedly made in the context of a socialist society) that each scientist has own path towards communism ("Collected Works", Volume 32, pp 137-45, the question is whether the systems approach as described by Ackoff, *op cit*, represents, in however halting a way, an advance from the metaphysical mode of thinking, described by Engels in "Anti Duhring", Progress, Moscow, 1975 p 29, towards dialectical materialism.

5 Kalecki, it now appears, reached Keynes's conclusions almost simultaneously, but Keynes is certainly the person with whom interventionist policies are generally associated.

6 Beer, *op cit*, pp 277-279.

7 For the defensive character of early English OR, see F N Trefethen, 'A History of Operations Research' in J N McCloskey and F N Trefethen, "Operations Research for Management" Johns Hopkins Press, Baltimore, 1954. Also, see Beer, *op cit*, pp 128-134, for a discussion of the specific advantages of an application of a model taken from fluid dynamics.

8 See W Ross Ashby, "An Introduction to Cybernetics" Methuen, London, 1964, pp 53-54, for a definition of feedback, independent of physical or electrical connections, as an example of this approach.

9 "The weak points in the abstract materialism of natural science, a materialism that excludes history and its process, are at once evident from the abstract and ideological conceptions of its spokesman, whenever they venture beyond the bounds of their own specialty." "Capital" Volume 1, Progress, Moscow, nd p 352, fn 2.

10 A more general point was made at a conference on "Operational Research and the Social Sciences", where the OR point of view was accused of threatening the private property system when followed to its logical conclusions. See, J R Lawrence (*ed*) "Operational Research and the Social Sciences", Tavistock, London, 1966, particularly pp 297-304.

11 See Trefethen, *op cit*, for evidence of the speed of advance of OR under wartime conditions. Beer in "Decision and Control", discusses the degradation of much of post-war OR work. See particularly Chapters 1-5.

12 Beer, *op cit*, pp 19-20.

13 Ackoff, *op cit*.

14 *Ibid*.

15 See comment by Marx cited in Note 9.

16 Noam Chomsky, 'Linguistics and Politics', *New Left Review*, 57, pp 21-34.

17 See Trefethen, *op cit*, pp 33 for an early application of OR to integrated industrial development in Puerto Rico.

18 This distinction has been clearly made by W R Buckland in his review of D J White's "Decision Methodology", *Operational Research Quarterly*, (27, 1, 11), p 274.

19 A clear definition of Operations Research is to be found in C West Churchman *et al* "Introduction to Operations Research", Wiley, New York, 1957 pp 6-8.

20 V G Afasnasyev, "The Scientific Management of Society", Progress, Moscow, 1971.

21 For a discussion of the philosophic basis of the 'Human Relations School' see D Gvishiani, "Organisation and Management", Progress, Moscow, 1972, N Bogomolova, "Human Relations' Doctrine: Ideological Weapon of the Monopolies", Progress, Moscow, 1973; and H Braverman, "Labour and Monopoly Capital" Monthly Review Press, New York, 1974.

22 See Russell A Ackoff 'The Social Responsibility of Operational Research', *Operational Research Quarterly* (25, 3), pp 361-371 and the debate in following issues.

23 Charles J Hitch 'Plans Programmes and Budgets in the Department of Defence', *Operations Research* (10, 1), pp 1-17.

24 The presence of various social groups within capitalist society makes it essential to devise some normative utility indices to measure payoff. These are often anti-humanist and have rightly been attacked.

25 Afasnasyev, *op cit*, Chapter 3.