A Career in Operational Research

Notes based on an interview with John Stringer by Professor Brian Haley, on behalf of the Operational Research Society for their archives , March 2004

John Stringer's life has run in parallel with the development of OR. He not only pursued a career which contributed to the development of the subject but also was influential in a number of major new ventures. It is natural that throughout his life he met and worked with a number of other influential members of the Operational Research community who also shared his interest in the development of the subject.

He was born near Wolverhampton and his early education was at Wolverhampton Grammar School (1936-43)[1]. He then went to St. John's Cambridge with a mathematical Scholarship to read for a war-time degree in Mechanical Sciences[2].

In 1945, on graduating with a first, he was posted to the Marine Aircraft Experimental Establishment, Felixstowe, for experimental work on flying boats. In 1948 he moved to the British Iron and Steel Research Association (BISRA) where he was appointed as a fuel technologist to work on efficiency of mill furnaces. Studies into the flow of ingots from casting to rolling used rudimentary concepts of simulation. They also convinced him that fuel efficiency was as much a matter of management as of thermodynamics and introduced him to the concepts of OR. These had permeated throughout BISRA largely under the influence of its Director, Charles Goodeve, who encouraged all parts of the organisation to embrace OR ideas.

London Transport 1950-1955

John was recruited to take charge of OR studies in London Transport by the Chief Development and Research Officer, FAA Menzler. Menzler was a distinguished actuary, President of the Institute of Actuaries 1950-52, who had urged the actuarial profession to take up OR (albeit not under that name) as early as 1924[3] and under whose influence LT was ahead of most organisations of the time in use of statistical

London Transport

LT had been nationalised in 1934, absorbing the London General Omnibus Company (LGOC) and other bus companies, the Tube, and the District and Metropolitan Railways. When the British Transport Commission was created after WW2, LT was the only part with any experience of nationalisation.

By 1950, when JS joined, LT had recovered from the worst effects of the war but there was a lot of obsolescent rolling stock, both road and rail, of various designs. Major projects in hand included completion of the 1935-40 new works programme of tube extensions; design and procurement of new buses and trains; replacement of trams by buses; planning new tubes (the first to be built being the Victoria line, known then as route 'C').

The area served extended from Luton in the north to Crawley in the south. There were 10,000 buses and coaches, 500 trains, and 100,000 employees. A great deal was done in-house that would nowadays be 'out-sourced'. An example is the development and design of the Routemaster bus. In the early 1900s LGOC had formed the Associated Equipment Company (AEC) to build its buses and although this was now an independent company making trucks as well as buses, a close relationship continued. The Routemaster was designed in every respect for London conditions, and for a 30 year life. Many of them are still on the road today (2004).

Petrol was rationed until 1952 and there was no TV. People used public transport to and from work and for entertainments such as the cinema, so services were used intensively.

Altogether, LT was a proud organisation permeated by a strong sense of public service and a tradition of pursuing quality and efficiency. The influence of its pre-war guiding spirits, Lord Ashfield and Frank Pick, could still be felt in 1950.

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[1] Maurice Shutler was to follow him as a pupil

[2] one contemporary of his, Rolfe Tomlinson, was much later to transfer from Statistics to head OR in the NCB. Another, Leo Govier, worked in OR at Esso

[3] See Menzler's obituary http://www.actuaries.org.uk/files/pdf/library/JIA-095/0177-0181.pdf
He joined the Underground group in 1929 and retired from LT in 1954.

methods and in the financial analysis of investment projects. OR worked to the Research and Development Committee, composed of the Chief Engineers under Menzler's chairmanship. They, often at the request of one of the operating departments, would agree terms of reference and set up an *ad hoc* team for each study comprising representatives from the relevant operating, engineering, and other departments, with John as secretary and, usually, a statistician drawn from the group under Bill Buckland who was also in Menzler's department. Teams of inspectors could be borrowed for field observations. Early projects were concerned with the interaction between passengers and vehicles, for example speed of boarding and alighting, minor accidents, luggage, and the usefulness of destination indicators. The variety of vehicles of different designs still in service made it possible to learn from comparisons.

With new tube lines being planned, questions arose about the maximum frequency of service that could be run and another early move was to re-constitute the Line Capacity Committee, under the chairmanship of the Commercial Manager, David McKenna[4] who had been its secretary pre-war. John became secretary. Under these auspices some experiments took place (see box) that were still remembered when John visited LT forty-five years later!

Another railway project was concerned with factors affecting the energy consumption of trains. A statistical analysis of substation meter readings and signal box records showed *inter alia* that the practice of running shorter trains in off-peak hours, common pre-war and recently re-introduced, saved little energy but had caused the increase in kWh per car-mile that had given rise to the inquiry. The reason, of course, is that much of the resistance a tube train has to overcome is due to the piston effect and does not depend on its length.

Under the influence of Charles Goodeve, who was a member of the Transport Commission's Research Advisory Committee[5], traffic delay at road junctions became an object of study and Peter Welding[6] was appointed to concentrate on this. Detailed observations were made on a cross-town route to establish the frequency of stopping and other symptoms of traffic congestion. This, together with theoretical and observational studies of traffic lights, in liaison with the Road Research Laboratory, gave a better understanding of traffic engineering but did not lead to the proposals for re-phasing of traffic lights which Goodeve had hoped for. This understanding did, however, contribute to later work on regularity of bus services (see box p 3.)

Line Capacity

Speed-sensitive signalling was one idea. Trains would be allowed closer together the slower the one behind was going and the faster the one in front was drawing away. Traditional signalling assumes the one in front to be stationary and the one behind at full speed.

There was no such system in existence, but calculation showed it would increase the frequency from 40 to 42 trains per hour. But 34 was all that was being achieved in practice, and investigation of the difference might reveal scope for improvement without new types of signalling.

Calculation now being suspect, an experiment was mounted on the Bakerloo line. A special timetable was written feeding 40 trains in at Baker Street in an hour. 30-second station stops were enforced so as to reproduce the assumptions of the signal calculations. Observers were placed in cabs and on platforms to record all movements.

In the event, 38 trains entered, but only 34 emerged in the hour i.e. a queue had built up. Analysis of the timings showed that, whereas it had been assumed that trains would decelerate smoothly to stop at the end of the platform, drivers usually brake sooner and crawl the last few yards. A few seconds lost in this way could not be recovered.

The outcome was to drop the speed-sensitive signalling idea and, for the new Victoria Line, to automate control of braking and acceleration.

[4] Menzler once told John one of the reasons he was selected was that he had the same degree as McKenna. There the comparison ended, McKenna was the son of a Chancellor of the Exchequer.

[5] RV Jones, another wartime OR scientist was also a member.

[6] Peter went on to OR at British Rail and later became Chairman of the transport planning agency in Brisbane. He was one of the first to greet John in Australia when he arrived there in 1976

The Research Advisory Committee also introduced the emerging discipline of Ergonomics. Sir Frederic Bartlett, Professor of Experimental Psychology at Cambridge offered to provide some training and John spent a long vacation studying in his laboratory. This experience provided useful background for several OR studies, some of them in collaboration with the medical department.

One of these concerned the design of the driving cab for the Routemaster bus, another the supporting harness (but not called that!) for the Gibson ticket issuing machine, a somewhat cumbersome piece of equipment carried by bus conductors. A digest of the literature on accident proneness was another outcome of the introduction of a psychological element into OR.

The fuel consumption of buses, a major operating expense, had long been an interest of the research department. Monitoring, using statistical quality control methods, was well established as was a methodology for research on technical changes, such as low viscosity lubricants, using statistically-designed service trials. This provided background for an OR project on the effect of driving style on fuel consumption (see the box on p4). It is a good example of how, with an in-house OR activity, the studies complement one another and, over time, build up a rich scientific understanding of the system concerned.

Regularity

Why do buses often run in bunches, and what can be done about it? The Operating Department had a team of inspectors who would observe the percentage of buses within ±2 minutes of the scheduled time at points on their route. They would hold back any that were running early, but there was little else they could do.

They were, of course, only measuring 'punctuality', so a measure of 'regularity' was devised by considering the average time an intending passenger arriving at a bus stop would wait for the next bus.

Using AWT (average waiting time) observations were made on a busy route. AWT was found to be worse than if the buses came in a random (Poisson) stream! In one case, a bunch of two buses in the early morning had grown to 14 by mid-afternoon.

A possible mechanism was variability of traffic delays in that once a bunch started to form, for whatever reason, buses in it would meet similar delays and so stay together. To test this, a paper simulation model was created, using statistical distributions of traffic speeds from the Road Research Laboratory. This generated similar bunching patterns to those we had observed.

The solution would be to extract some buses from a bunch going one way and inject them into a gap coming the other way. This would require a controller with a full picture and the authority to pass commands to bus crews.

This was beyond the technology of the day (G PS and cellular telephony would make it easy now).

Reducing the scheduled frequency and using the buses saved to increase the layover at each terminus would also reduce AWT but the operators could not bring themselves to do this.

The simulation was later programmed on one of the few computers then available, the Ferranti Mk1* at Manchester, but having set this up John had left before results were available.

Looking back, one can see the factors that facilitated introduction of OR to London Transport. Internally, Menzler was a powerful force both intellectually and by virtue of having been close to the centre of things for many years. He maintained, incidentally, that as a nationalized monopoly not subject to competitive pressures, London Transport had a particular need for OR to keep it efficient. After Menzler's retirement in 1954, the Research and Development Committee no longer met. Its sponsorship and support had been vital at the early stages, and had enabled O.R. to become established and able to stand on its own feet.

The influence of Goodeve and others who were championing OR at this time can also be seen both through the BTC Research Advisory Committee and through the OR Club. The Club had expanded to 70 members at about this time and was restricted to one member per organization. Menzler represented London Transport but John often attended in his absence and was able to make many supportive contacts particularly in Road Research and the Airlines.

Driving and Fuel Consumption

Questions were raised prompted by articles that appeared in the press saying that up to 25% of fuel could be wasted by bad driving practices. The first step was for a team of driving instructors riding incognito made a survey of the prevalence of these practices considered to be wasteful such as 'driving on the brakes'; lazy gear-changing; and on-off bursts of acceleration. But this left the question of whether, and by how much, these practices were wasteful.

Next, a programme of tests was undertaken, at the Motor Industry Research Association proving ground at Nuneaton. This involved four buses and four drivers and four levels of passenger loading (simulated by sandbags) in experiments designed to separate the variances due to these factors from those being investigated. Over a three-week period spent circling the track in convoy, the effects of frequency of stopping, speed reached between stops and the (supposed) bad practices were measured, yielding a body of data that was later found useful for a multitude of purposes.

Taken together, the survey and tests suggested that stories about wasteful driving had been greatly exaggerated and in some cases failed to recognise the difference between a bus and a car. For a bus, working to a schedule and making frequent stops, it is more economical to accelerate rapidly to a modest speed, and to brake quite sharply, than to accelerate and brake more gently and thus have to reach a higher speed to make up time. But the scope for doing this is constrained by traffic conditions.

The final step of the investigation, therefore, was to use the test results together with data from traffic studies about the distribution of distances between stops (averaging about 6 stops per mile taking traffic and passenger stops together) to calculate a minimum fuel consumption for the fleet as a function of schedule speed (distance÷time terminus to terminus). Although not realised at the time, this calculation was an example of the 'dynamic programming' method of optimisation.

This final stage of the investigation showed that the actual fleet fuel consumption was within about 2% of the calculated minimum, and put an end to talk of wasteful driving. What the project had provided was a body of data of continuing usefulness, for example factual data on the effect of changes in schedule speed.

Central Electricity Generating Board (and its predecessor) 1955-62

John was appointed in 1955 to set up "O.R." in the Central Electricity Authority (later CEGB.) The salary offered was attractive and he recalls that the candidates interviewed included Cook, Eddison and Taylor[7]. It turned out that his employers had confused OR with Work Study which was being strongly promoted by Russell Currie at I.C.I.[8] In consequence he was located in the Generation Operations function, since the majority of the workforce were employed in power stations, rather than in a cross-functional position like that at London Transport. This tended to constrain the range of problems offered. It seemed to him that, as ratio of capital assets to employees in electricity generation was about ten times that in industry generally, work study concentrating on labour productivity was not particularly appropriate and he devoted much of his effort to promoting a better interpretation of what O.R. meant. Initially, however, the structure that had been set up was more appropriate for work study.

In addition to John's team at headquarters, there were to be small teams in each of the twelve divisions covering England and Wales. All were mainly composed of engineers[9] recruited internally and John was expected to advise on their selection and training. Because work study was a sensitive subject from an industrial relations point of view, undertakings had been given that 'work measurement' would not be used and that the teams would concentrate on 'method study'. For the same reason, it was expected that studies would be negotiated through the extensive joint consultation machinery (see box on p5).

[7] all of whom became particularly active both in the Society and instrumental in developing OR in their respective companies.

[8] Currie banned the use of the title OR from I.C.I. and especially Metals Division even though Pennycuik and Purdon were employed to carry out OR there during this period.

[9] Statisticians, mathematicians, etc. would rank as clerical staff, on inferior pay, and so were difficult to recruit.

The Electricity Supply Industry

Before nationalisation, the industry comprised private companies; the municipal undertakings serving major cities and surrounding areas; and the Central Electricity Board, set up in the 30's to build and operate the national grid.

All were absorbed into the British Electricity Authority in 1948. Distribution and sales functions were devolved to semi-autonomous area boards. Generation and high-voltage transmission remained a central responsibility organised in divisions, co-terminous with the area boards, with a strong headquarters department under the Chief Engineer.

The Chairman of BEA, Lord Citrine, was a former General Secretary of the Trades Union Congress and his Deputy, Sir Henry Self, a former civil servant. The organisation they set up was run by committees and conferences, and included elaborate joint consultation machinery.

In 1955 Scotland hived off and the name changed to Central Electricity Authority.

A major reorganisation took place in 1958. The Area Boards became fully autonomous and the Central Electricity Generating Board (CEGB) was created under the Chairmanship of Sir Christopher Hinton. Divisions were amalgamated into five Regions whose Directors were given considerable powers. The Electricity Council was formed to speak for the industry, but its powers were weak and the boards dealt with government direct. The plethora of committees disappeared.

See:- Hannah, L (1982) *Engineers, Managers and Politicians – The first 15 years of nationalised electricity supply in Britain,* MacMillan.

Training was partly by courses and partly by example. A special course in OR was arranged at Southfield, University of Birmingham[10] but it would have been impolitic to miss out Work Study. John took up personally an offer by Currie of a place on a course at ICI and Frank Tasker, one of his staff, went to Cranfield. A course in Method Study was held at Strathclyde.

Example was perhaps more influential. John seized on Haley's work applying Linear Programming to coal transportation[11] as 'proper OR' and through the Divisional teams spread its application country-wide. Of longer-term significance was work on plant overhauls (see box).

Plant Maintenance

When plant is out of service for overhaul, less efficient plant has to meet the electrical load. There is thus an economic incentive to reduce the time taken. An early problem put to the HQ group was whether extra labour, bigger stocks of spares, etc. would be economic. In collaboration with the Yorkshire OR team, the overhaul of a modern boiler-turbine set was observed in fine detail over its four-week outage. The results suggested that the job could have been done in under half the time and that with extra labour an outage of five days should be possible (a 'longest irreducible sequence' concept was used, adumbrating the now-familiar 'critical path' model.)

The cost of extra labour would not be economic in this case but, with much larger sets about to come into service, would become so. Experiments were therefore arranged in the Midlands to demonstrate that the theoretical limit could be reached. This took a great deal of planning, including getting trades union agreement to borrowing staff from other power stations. The outcome was a success and the point was made. Meanwhile the Yorkshire group had followed up the first study and the two-week overhauls were regularly being achieved. The magnitude of these results was such that they could not be ignored. Through the network of Divisional OR teams, the improvement spread across the country over the next few years.

Further work on this theme included a calculation of the optimum overhaul programme, given the constraints of load demand and the statutory requirements for the interval between inspections of boilers and pressure vessels.

With the creation of the CEGB the original difficulties over Work Study and Joint Consultation were left behind. The Regions now had a greater degree of autonomy but the personal network that had been established remained effective. There was no formal machinery

[10] There was very little university-based OR at this time. The Department of Engineering Production at Birmingham were one of the first to take it up.

[11] In December 1954 Haley had worked on the distribution of coal from collieries to power stations for the Midland Region and this was one of the examples used in the joint paper presented by Stringer and Haley in Oxford in 1957

for initiating OR projects and the HQ team were drawn into a variety of jobs such as a review of the headquarters organization and the organization of purchasing. John saw signs that it would not be long before he was moved to a general management job and, not feeling comfortable with this, felt it was time to move on. He records that Arthur Hawkins (Chief Operations Officer, who later became Chairman[12]) introduced the farewell address given to him with *"I'm not sure what O.R. is but it spells 'or' and when I suggest we do something John responds with 'or we could do' ... something else"*

Contacts with the external OR community did not play the supportive role they had in the case of London Transport, but were nevertheless significant. In 1956, soon after his appointment, John was one of two CEA delegates to an international conference of the CIOS[13] in Paris. One of the sessions was on OR but the paper, by an American, made no reference to British achievements or, indeed, to mainstream OR in the US. The UK OR people there[14], including Steve Cook and H G Jones, mounted a protest.

At Goodeve's invitation, John served on the organizing committee of the first International OR Conference, at Oxford in September 1957. John remembers this as the only conference where he knew everyone by name and had read all the papers. One of the most significant results for the OR Society - as it had now become - was that John was asked to chair the first conference committee and was responsible for organising OR1 which took place in Harrogate in 1958.

British Oxygen Company 1962-64

The last of his industrial appointments was as OR Manager at BOC. The preceding incumbent had not been regarded as successful. John was located at the Research base in Morden, Surrey, but most of the work was for the Operations Chief, an ex-Brigadier[15]. Sir Owen Wansbrough-Jones, who had been President of the ORS when John was on the Council, was a member of the Board and there was a good understanding of what OR was for.

Most of the work was concerned with delivery scheduling and related matters. A study to find the best location for a fourth delivery depot to serve the London area showed it should be put at Morden! This was an awkward conclusion, but it did come to pass some years later.

BOC had for many years been a monopoly and had recently been the subject of an investigation by the Monopolies Commission, who had criticised the lack of a transparent price structure and the quantity discounts offered to certain favoured customers. A working party, consisting of the company's economist, an accountant, a salesman and John, was formed. They proposed a three-part price structure with charges for delivery, the rent of cylinders, and the gas itself. This gave a universal structure that recognised the markedly different costs of serving large and small customers. Many years later John found it still in use in the Australian subsidiary.

John was active in the ORS, serving on the membership committee which in 1963 vetted members who were seeking to be admitted or promoted to full membership. Neil Jessop who

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[12] In later years Hawkins came to IOR for several assignments. One of these, on *A Predictive Information System* was published in ORQ.

[13] Congrès Internationale d'Organisation Scientifique. In view of the prestige of CIOS, the Treasury relaxed the controls on currency exchange. Hospitality was in the best French style.

[14] Currie was also there!

[15] The Deputy Chairman was Lord Reith, the founding Director-General of the BBC, erstwhile Chairman of BOAC, etc. Reith was a more forceful figure than the Chairman and was keen on recruiting army officers, especially from his old regiment. Wansbrough-Jones had been at school with Reith.

chaired the committee had just become Director of the Institute for OR and in response to John's enquiry as to progress received the reply 'why not come and join us' which he did in 1964.

Recruitment to BOC of staff with OR experience had proved difficult and under a mutually convenient arrangement John continued to give part of his time to the company for a while.

Institute for Operational Research 1964-76

IOR had been set up following a long campaign by Neil and others to persuade the OR Society to foster OR in the social and public sectors and to add social sciences to the disciplinary mix of OR. Russ Ackoff[16] had introduced the ORS and the Tavistock Institute to each other and it was in that Institute that Eric Trist and colleagues developed the concept of 'socio-technical systems' which had a potential synergy with OR. IOR was founded as a separate unit within 'Tavi'. Goodeve was invited to the Tavi Council and to chair the OR Sub-Council.

The exciting potential of the new venture enabled Neil to bring together a team of experienced OR scientists. There were no funds for fundamental research and survival depended on generating income through research grants and consulting projects. The Nuffield Foundation had declined a request for institutional funding but offered to fund a major four year study of planning and decision making in the City of Coventry. The results included the publication of a book "Local Government and Strategic Choice" by Neil Jessop and John Friend. John Friend and Paul Spencer (an anthropologist) had lived with the official and political 'tribe' of Coventry and 'told it as it is' in contrast with the usual descriptions of how the public sector is supposed to work. Sadly, Neil died a few days after the publication in 1970 but John Friend continued with a series of projects leading to the development of the Strategic Choice methodology[17].

The second major study, jointly with Gurth Higgin (a social psychologist), was called 'Communications in the Building Industry'. An elaborate structure was created, with a Project Committee chaired by Lord James; trustees under Lord Holford and a steering committee under Andrew Derbyshire[18]. However the problems and expectations were ill defined and the main groups in the industry (builders, architects, suppliers, surveyors, etc.) differed as to the purposes of the research. There was a marked parallel in behaviour between the meetings of these committees and the typical progress meetings on a building site. Finally, the trustees ran out of money and defaulted on the IOR bill. A few smaller projects were offered by sympathetic sponsors, and some ideas were salvaged and incorporated in the Strategic Choice work and in John Stringer's later work in Australia on management of large projects.

The third group of projects grew out of an approach by the Ministry of Health seeking to know how OR could contribute to improvement in hospital management. They were not happy with a proposal for a 'Coventry-like project' but when John joined IOR and took over the negotiations did accept a two year project on 'Adaptation and Change' which consisted of four case studies. Before it was completed, Birmingham Regional Hospital Board commissioned a study into the setting up of operational polices for the new Walsgrave Hospital in Coventry. After the 'Adaptation and Change' report had been refereed a follow up five year programme was offered and accepted. This inevitably meant that Health became a major part of the work of

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[16] John had derived great benefit from a course on OR Methodology which Russ ran at Southfield, Birmingham University, in 1961.

[17] This is encapsulated in Friend & Hickling *Planning Under Pressure* (1987). A third edition to be published by Elsevier is now in preparation (July 2004)

[18] Lord James was Vice-Chancellor of the University of York, whose buildings were designed by Andrew (later Sir Andrew) Derbyshire. Lord Holford was a leading Town Planner.

IOR[19] especially when further studies were obtained from the Scottish Office. John himself became involved with the World Health Organisation in Europe and Colombia and later in NSW.

John presented a paper to the TIMS conference in Warsaw in 1967 describing some of these early experiences and discussing the difficulties of obtaining access to messy problems rather than just serving the, often non-existent, 'decision-maker'[20].

It became clear that IOR had to recruit some younger staff with OR degrees, which had not been available when the older members started. IOR could not get projects without people but without projects they could not afford people. Once again Goodeve came to the rescue, negotiated a loan from an investment bank and persuading a number of companies to set up an 'Industrial Basic Research Fund' which both gave the money for 'blue skies' work and also provided a panel of OR group heads to support the work[21].

External influences, however, were to take a hand. A Royal Commission under Lord Fulton had reported on the Civil Service and the Civil Service Department was created with a sizable OR unit under Ken James (ex AORE). John urged Neil to make contact with Ken and as a result James Morgan and John Pollard were seconded to work under Neil's general supervision in CSD to tackle some of the supposedly intractable problems, in particular in the field of Manpower Planning, and this involvement grew. One major input was providing a methodology for the dispersal of the Civil Service from London, and this grew into a major project into which most of IOR were drawn.

The story of IOR has been published elsewhere[22] and its files are lodged in the ORS archives at Warwick University so there is no need to elaborate further here. By 1975 John had worked for 11 years at IOR, six of them as Director, and had the largest unit of the Tavistock Institute, with 20+ people based in London, Coventry and Edinburgh, and a busy programme of mainly short term government projects. Feeling it was time to move on, at the age of 50 he answered an advertisement about the newly-founded Australian Graduate School of Management and within a few months had become an academic and an Australian. A new chapter opened.

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[19] The early work was published in Luck, Luckman, Smith and Stringer (1971) *Patients, Hospitals and Operational Research* Tavistock Publications

[20] *OR for Multi-Organisations* was published in JORSA, awarded a bronze medal by the ORS, and republished in the 50th anniversary volume of JORSA

[21] One outcome was: Luck, Morgan, Farmer and Stringer (1971) *The Management of Capital Investment* JRSS(A) Vol 134 No 4

[22] Friend, Norris and Stringer (1988) *The Institute for Operational Research: An Initiative to Extend the Scope of OR* J Op Res Soc Vol 39 No 8