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TOWARDS AN APPLICABLE HUMAN GEOGRAPHY: SOME DEVELOPMENTS AND OBSERVATIONS

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1. INTRODUCTION

The last thirty years have witnessed the development of model based methods in geography, regional science and allied disciplines. Although quantitative human geography is generally associated with this period, coinciding broadly with the 'computer-age', a concern with location analysis goes back much further, to von Thunen and Ravenstein in the nineteenth century and Weber, Christaller and Losch in the first half of this century. It is interesting to note at the outset that these early location theorists were concerned with problem solving - von Thunen, for example, was a practising farmer - and an interest in applied analysis is a theme that will recur during this paper.

The modern period of quantitative human geography has been characterised by a number of phases or cycles, some where computer-based modelling has experienced popularity, others when it has been largely ignored. A good account of this is provided by Batty (1979). More particularly the relevance and applicability of model based methods have been called into question on a number of grounds. Philosophical critiques (eg Sayer, 1978) have accused modellers of having undesirable associations with the discredited positivist school. Attacks have been made on pragmatic grounds - the models have simply not lived up to the claims of their advocates, or more succinctly, they do not work (eg Lee, 1972). Additionally, through ignorance and petty prejudice modellers are derided for being unfashionable and encouraging a status-quo view of the world.

Some of this criticism is valid, but a general effect of this broad attack has seen the modelling fraternity diminish in numbers

and in confidence within the discipline, though to a lesser extent in the wider world. As a consequence the contribution of model based methods, particularly in human geographical teaching, has declined to a state where many would now see it as marginal to the discipline. In this paper we wish to demonstrate that this neither is nor should be the case. For a number of reasons there is evidence to suggest a resurgence in the development and application of model based methods. This is occurring in both traditional areas of model application but most importantly in a range of new systems which provide both challenges and opportunities for locational analysis. We select a number of these for discussion in section 4.

The main argument of this paper therefore is that the time is ripe for the promotion of an applicable human geography underpinned by model-based analysis. This will have as a principal feature a concern with both policy and planning issues in a number of different systems as well as a fundamental interest in how these systems work. Again, in section 4 this concern with description and analysis, along with a prescriptive focus will be illustrated through a series of examples.

The rest of the paper is structured as follows. In section 2 we briefly describe some of the main periods of model development in the last 30 years and examine some of the criticisms directed towards the use of models in planning. We then describe some recent developments that suggest a renewed interest and demand for model-based methods. We note that this demand is stimulated partly from the traditional concerns of urban and regional planning, but perhaps

most strongly from new areas in both the public and private sector. The fact that an applicable human geography should be concerned with a large range of different types of systems is a reflection of the richness of human geography in terms of the possible range of subsystems it studies. This generates an inevitable pluralism of approaches and we emphasise that our applicable human geography is but one of a myriad of approaches and thus should be seen as complementary rather than competing with other styles.

Section 3 attempts to demonstrate the relevance and importance of spatial analysis in contemporary society. Our focus is twofold - on analysis and prescription - and we highlight how a wide variety of systems have a number of important features in common. In particular these relate to the fundamental spatial relationship between supply and demand for products or services and the consequent patterns of spatial interaction as a result of consumption. Additionally, we shall show how recent research and development of performance indicators can assist in the planning of these systems. Section 4 then examines a diverse range of systems in which the authors have undertaken research to illustrate the main arguments by example. These are health care planning, education, financial services, retailing, the utility industries and leisure and recreation.

Section 5 outlines a set of pre-requisites and desirable developments that would enable and encourage the development of such an applicable human geography. We also feel that there are a number of spin-offs that would emerge from this development. In particular, it naturally leads to a new kind of regional geography

in which the conjunction of qualitative and model-based analysis for a range of systems provides a powerful framework for the understanding of local regions. The various threads of our argument are drawn together in the concluding section.

2. BACKGROUND TRENDS AND DEVELOPMENTS

2.1 Phases in the development of computer models: to the 1980s

The first phase of the development of computer models in urban planning occurred in the mid-1950s in the USA. This period of time was marked by a massive increase in car ownership and the consequent expansion of the urban highway network. The realisation that there existed a deep and subtle relationship between land use and transportation generated a demand for analytic methods. This was satisfied, in the first instance, by civil engineers using very simple models but these quickly grew more complex. Two notable publications which did much to generate wider academic interest in the subject were Hansen's 'How accessibility shapes land-use', published in the Journal of the American Institute of Planners in 1959 and Lowry's 'A model of metropolis' published by the RAND Corporation in 1964. It is worth noting that these developments took place outside of geography. The period was one of great optimism for the future of model-based planning methods.

The second phase we can identify may be loosely described as 'Statistical Description'. In the early 1960s, geographers discovered that many simple statistical methods had important applications in spatial pattern analysis. These techniques, such as

point pattern analysis, nearest neighbour analysis, rank correlation and regression, quickly established themselves in the geographer's toolbag of methods, notably following the publication in 1965 of Haggett's 'Locational analysis in human geography'. As the decade progressed the tools became more refined with multivariate methods such as factor analysis emerging. Although it is often pointed out, it is worth repeating that the so-called Quantitative Revolution was always more of a statistical than a mathematical one. Much of this statistical work continues today particularly through the methods associated with discrete choice theory and categorical data analysis (eg Wrigley, 1986, Wilson and Bennett, 1986).

A third phase ran parallel with the development of statistical methods in geography. This saw the diffusion of methods from North America to the United Kingdom in the 1960s. Again this was not focussed centrally within geography or indeed in universities: the majority of research was undertaken in planning activities in a variety of central and local government departments or in quasi-government organisations such as the Centre for Environmental Studies. As a consequence, much town planning in Britain for a period became quantitative and often model-based: this was most clearly expressed in the Structure Plans prepared by Local Authorities. A significant conceptual step in this period was the derivation of a wide family of spatial interaction models using entropy maximising methods (Wilson, 1967, 1970). This gave the 'gravity model', already of considerable interest to geographers, a clearer theoretical foundation and enabled mathematical methods to

be established within human geography alongside statistical techniques. Much applied work took place, developing, calibrating and applying land-use transportation models in particular to a variety of city regions around the world. This work was characterised by conditional forecasting, where the 'conditions' were representations of the planning policies being explored. Furthermore, attempts to construct comprehensive models took place. This was driven by the realisation, first formally recognised by Lowry, of the major inter-dependencies between sectors of the urban system and the consequent need to represent them in modelling.

The fourth phase, which may be called the Quantitative Backlash, can be identified during the 1970s. A number of influences changed the perception of urban modelling and its contribution to planning. First there was the liberal planners view that the relationship of model-based research to planning was less than satisfactory. The models had failed to live up to the claims that their proponents had made. On the one hand the problems of urban areas were getting worse and on the other, the models could demonstrably be shown not to work. This type of criticism is epitomised in Lee's (1973) paper 'Requiem for larger scale models'. The second influence came from the advent of radical urban geography dating from Harvey's Social justice and the city also published in 1973. It was argued that deeper structures in society determined urban change and that these had been ignored by modellers. Both liberal and radical critics commented upon the static nature of existing urban models, and in some cases methods were criticised on this ground alone.

A broader element of the radical critique was that the theory underpinning modelling was simply wrong. Put at its strongest (and sometimes naively), there was an associated implication that anything 'mathematical' was 'scientific', and therefore 'positivist', and therefore wrong. More productively, it can be argued that urban modellers failed to build on theories related to the main agents of urban structure and development and relied too much on crude neo-classical economic foundations. The first part of this criticism certainly has substance; the second was often applied naively to models (such as most of those used in this paper) for which this comment was not true. It is better simply to agree that modelling offers a set of tools for handling complexity, that theory should be as realistic and effective as possible and that the skills of the modeller are likely to be relevant whatever the theoretical base (cf Sheppard, 1987 and Webber, 1986, Webber and Tomlin, 1987 for illustrations of this).

The response to these criticisms came in a number of forms, three of which are worth raising here. First, came the development of dynamic modelling and a concern with structure (in one particular sense). Rapidly developing ideas of nonlinear dynamic modelling were introduced into urban modelling (Harris and Wilson, 1978, Wilson and Clarke, 1979, Wilson, 1981). Not only did this generate new extensions to existing models but it also changed the perception of models and their contribution to planning. This brings us to the second response. It became clear that conditional forecasting was inadequate because of the high dimensionality of possible future

system trajectories, involving bifurcations at critical parameter values. This produced a deeper understanding of the relationships between modelling, theory and reality and led to new thinking on the applicability of model-based analysis. We take up these issues in section 3. These developments in modelling enable issues of 'theory' to be separated from these of modelling skills. Indeed, it is interesting that the understanding through dynamic modelling of the combinatorial structures of system trajectories offers insights into the relationship between 'general laws' and 'historical specificities' - the old uniqueness/generalist debate in geography - which are as relevant to Marxian theory as to neo-classical spatial economics. And, as yet, they have been properly absorbed by neither! We feel these responses bring the 'two sides' nearer together through a major concern with structure and an interest in hypothesis extension.

It can be argued that a new phase of model development and application is now in progress and this is described below.

2.2 The re-establishment of modelling: the 1980s and beyond

The effect of the considerable criticism directed towards urban modelling was to cast the field into a kind of 'Dark Age', where developments in model-based methods were carried out by a relatively small group of researchers. However, for a number of reasons, there is a resurgence of interest in the application of quantitative methods. At least eight reasons for this are identifiable.

(i) Improvements in traditional methodologies have been made

combined with much better experience in using them. In this context the field has matured and some of the worst excesses of model application have been avoided. Notably there has been a much more realistic view of the possible contribution of models to the planning and policy making process, reflecting the move away from conditional forecasting.

(ii) There has been the introduction of new methods for the exploration of conventional problems. For example, microsimulation methods (Clarke and Holm, 1987) have enabled distributional impacts of social and economic policies to be examined in detail and novel applications of Q-analysis enable the deeper structures of data sets to be explored.

(iii) Developments in information technology and associated information systems have enabled modellers to access relevant data sets quickly and easily. For example, SASPAC (Small Area Statistical Package) has provided on-line access to the 1981 Census for University and Local Authority users. Not all the developments in information technology are encouraging however. As Goddard and Openshaw point out (1987, this volume) the commodification of information implies that those without resources and appropriate technology are denied access to certain types of information. Additionally, some of the 'best' data sets on contemporary Britain are collected and held by private companies and only available at a significant

price. We return to this question in section 5.

(iv) As another aspect of IT advances, the development and diffusion of personal computers (PCs) has dramatically transformed model-based analysis. Earlier modelling effort was mostly undertaken on mainframe computers. The inherent difficulty of program transfer from one system to another prevented programs being generally made available to the research and user community. This is all beginning to change, and software dissemination to a wider group both in sectoral and spatial terms is now possible. PCs have also encouraged the development of user-friendly software and colour graphics which enhance both the use and appeal of modelling. The processing power of PCs will be significantly increased further by the introduction of 32 bit machines, such as the COMPAQ 386 over the next two years.

(v) The relationship between the modellers and the planning community has changed. There has been a realisation, already described, that conventional conditional forecasting does not work in the urban planning context because of the large degrees of freedom inherent in urban systems and the relatively minor element of control. However, there is a range of other planning systems, for example, health and education, where there is the potential for greater control and relatively less degrees of freedom. In these areas, where spatial models saw only

limited application in earlier phases, there exists tremendous potential for model-based analysis. We take up this theme in section 4. The same story can be told in relation to the private sector, in areas such as retailing and financial services.

(vi) Related to this is a growing recognition by managers and planners of public and private sector organisations that analytic methods have an important potential contribution to make to efficient and effective planning. This was partly instigated by the marketing of census-based demographic information such as ACORN and PIN. These systems, which have been well received in the commercial sector, have whetted the appetite for spatial analysis. As Goddard and Openshaw (1987, this volume) point out, much of what is being undertaken by firms of management consultants we would consider to be quantitative geography. (Perhaps this situation should be compared to the relationship between civil engineers and planners to geographers in the 1960s.) Tremendous opportunities exist for focussing attention on the contribution of spatial analytic methods and their role in understanding and planning society. At the moment quantitative geography is seen as only marginal to this. As we argue later a major marketing effort is required, but there is evidence that some progress is being made in persuading interested parties that geographers can contribute to problem solving and planning (see Beaumont, 1987, this volume).

(vii) One of the problems faced by modellers is making the outputs of their methods intelligible to the planner or manager. A major step towards solving this has been through the development of performance indicators (Clarke and Wilson, 1984, Wilson, 1985). Performance indicators can be seen as the outcome of transformations on either data or model outputs that relate stock or activity variables (eg number of unemployed, number of part-time female workers) to consistent denominators (such as the economically active population). They can also link demand and supply in a policy-interesting way. We discuss them in more detail in the next two sections of the paper but their development has stimulated a great deal of interest in both public and private sector organisations.

(viii) A general concern with applicability and relevance of geographical research is evident within the academic community. This is partly forced - as traditional Research Council funds dry up, it is necessary to seek a wider base of funding sources - and universities generally are encouraging links between academic and industrial and commerical partners. In this context the marketing of our skills becomes an essential part of the process. It is necessary to demonstrate an effective and credible approach to analysis and problem solving. An excellent lead is provided by the BBC Domesday Laser Disk system which is now available (see Openshaw, Rhind and Goddard,

1986). This provides an easily accessible nationwide information system which is easy and attractive to use. It naturally cries out for an associated analysis package and quantitative geography could benefit enormously by providing and marketing one. (Clarke and Openshaw, 1987.)

These eight factors (and related trends) do not in themselves herald a revolution in the role and appeal of model-based analysis, but they do suggest that fertile ground now exists. We argue that through the promotion of a model-based applicable human geography this opportunity can be grasped.

2.3 The richness of human geography

It is often stated that human geography is a very 'rich' subject in terms of the possible range of subsystems it studies and that this generates an inevitable pluralism of approaches. At a coarse level four main schools of thought can be identified in the recent history of the subject. First, a regional geography, broadly concerned with the synthesis of knowledge about places. Secondly, substantive systematic approaches focussing on particular subjects or theories, such as industrial and transport geography. Thirdly, spatial analysis as represented through statistical and mathematical modelling. Finally, and most recently, radical geography. Within each of these schools different styles have emerged which reflect the spatial scale of analysis, the degree of spatial representation and whether a partial or comprehensive approach has been adopted. It is also possible to distinguish distinct and sometimes overlapping streams of work appearing in some or all of these categories. For example, neo-classical and Marxian economics,

sociology, social physics and ecology make contributions to most of these areas.

It has been argued in detail elsewhere (Wilson, 1987) that an effort should be made towards structured pluralism in human geography. This can be seen, in part, as based on the different ways of structuring the subject matter of geography; and, in part, as the influence of different disciplines in formulating the approach to theory and method. It can also arise from the location of particular practitioners in geo-historical terms (neo-classical, model-based, radical). Currently, different schools tend to be rather insular - theirs represents the 'best' approach. There is a compelling need to break down the barriers between these schools for obvious reasons, (eg. the prevention of private language development) and for the positive benefits that accrue from stronger connections. We argue that this can be achieved through a three step approach. Each step involves a particular focus:

(i) on system definition

(ii) on theoretical or methodological approach

(iii) on utility of analysis, especially in a planning or policy context.

It should be clear that contemporary problems of location and spatial organisation can act as a stimulus for the development and application of new theory and method and contribute to policy analysis and planning. This should incorporate a variety of types of analysis, from the relatively mundane (eg the location of a new superstore) to the fundamental (eg restructuring of capital in the

global economy). It is our contention that a model-based applicable human geography can contribute to these objectives. We emphasise once again that our desire is for informed description, explanation and prescription, not simply the latter.

3. RELEVANCE AND IMPORTANCE OF SPATIAL ANALYSIS IN CONTEMPORARY SOCIETY

In this section we wish to describe the common features of a range of systems that characterise the contemporary economy and society. In section 4, we examine these systems individually in more depth. The systems chosen reflect our own research interests. It is by no means exhaustive, but we hope it is representative. Our aim is to illustrate that in these systems many of the important characteristics they share are of direct relevance to spatial analysis and that they constitute the subject matter of an applied human geography. We have chosen particularly systems where the potential for immediate wider application is high. There are others of major concern to human geographers where substantial progress has been made in theoretical terms (the beginnings of empirical work in some cases) which we omit - referring the reader to the literature for further information. These omissions include: agriculture (Wilson and Birkin, 1987); industry (Birkin and Wilson, 1986-A, 1986-B); housing and residential location (Clarke and Wilson, 1985). The systems we have chosen are different kinds of services and are:

(i) health care

(ii) education

(iii) retailing

(iv) financial services

(v) utilities, as illustrated by the water industry

(vi) recreation/leisure

The principles demonstrated here can easily be extended to other services. These examples are characterised by seven common features that we describe in turn.

(i) Spatial and temporal variation in need or demand

For all services, activities and goods there exists a clear spatial differentiation of need or demand. This occurs across a number of different spatial hierarchies: global, national, regional, urban, census ward, post code and so on. Spatial differentiation occurs for example, for reasons of demographic variation, income variation, cultural and class variation. Importantly, the revealed demand for certain services is also related to the availability of that service and accessibility to it.

Geographers have long been concerned with the variations in need and utilisation of services over space and a large body of literature exists on how it can be measured. More recently, market research organisations have had significant commercial success in converting small area census data into a small number of clusters which identify different social and demographic profiles. These systems, such as ACORN, PIN and SUPERPROFILE have been used extensively in marketing, direct mailing and site location as well as social research. (Beaumont, 1987)

The spatial variation in need or demand does not, of

course, remain static over time. Census data reveals the changing structure of the population and spatial demographic forecasting methods (Rees and Wilson, 1977, Clarke, 1986) enable us to predict future change. Change also occurs at a number of scales, from regional population movements, such as counterurbanisation, to metropolitan restructuring as the population moves out of the inner city. Importantly this is not homogeneous across different social and economic groups - the residual population in the inner city is characterised by the young and the old, the poor and underprivileged. Clearly, understanding and predicting this change is an important aspect of human geography.

Concern is expressed by both private and public organisations as to how the spatial demand for their goods or services is likely to change, so that appropriate planning and organisational changes can be made. Forecasting methods are therefore an essential feature of planning systems in a wide variety of situations.

(ii) Spatial and temporal variation in the pattern of supply

Acting both as a cause and as a response to population or demand change, the supply side of many systems has undergone spatial transformation. In retailing, the small independent shops and ribbon development have made way for the sueprmarket, the superstore, the integrated centre and most recently the

edge-of-town development. Hospitals have increased in average size and reduced in number. Employers have changed both the size and location of their workforces. In these, and other systems, there remain marked variations in the spatial pattern of location. The distribution of employment in many high-tech industries is concentrated in the M4 corridor, while in many northern towns principal employers are branch plants of companies having their headquarters in London or abroad. They are therefore more vulnerable to long-distance decision-making and economic factors outside the local environment. Again geographical methods can provide a powerful descriptive analysis of the distribution of supply and examine the consequences of future change. Spatial analysis can focus on issues such as the best location for a new hospital, the most profitable site for a new superstore and so on.

(iii) Spatial interaction

The consequences of the separation of spatial patterns of demand and supply is some form of spatial interaction. This is a ubiquitous feature of most socio-economic systems because activity involves the interplay of different actors distributed over space. Traditionally, spatial interaction methods have addressed flows of physical quantities, persons from residences to workplace, shoppers from home to store, goods from factories to customers and so on. However, in a number of systems it is the flow of information that is of growing

importance. For example, in banking there is an enormous increase (and this will continue) in the use of Automatic Teller Machines (ATMs). The paperless transactions involve the transmission of relevant information from thousands of remote sites to central computers and back again. ATMs are increasingly being provided in non-banking sites, in superstores, for example.

Patterns of all types of spatial interaction are changing for reasons described above. This has different impacts on different groups, such as car owners and non car owners and on access to retailing facilities as local centres decline and large purpose built edge-of-town stores develop. Understanding the changing patterns of demand and supply allow for an understanding of why patterns of spatial interaction change. Spatial interaction models can be used to examine the existing patterns and to forecast how future change could occur.

(iv) Technological change

Technological change enables activities to be undertaken in different ways and for new products and services to be supplied. The spatial impacts of technological change can be quite dramatic. In modelling terms, they will manifest themselves in the model's representation of the supply production function - essentially the cost relationship in a dynamic model. In retailing, for example, there are at least two aspects of

change: the first is through the consumer and relates to ease of travel (higher car ownership, motorway systems); the second to retailing technology and the costs per unit of selling goods in different kinds of store. Both factors have combined to generate a smaller number of larger, often decentralised, stores and centres.

(v) A planning/management requirement

Because of the rate of change, all organisations have to manage and plan their activities. As we have seen, they have to examine how the demand for their services is changing and how they are to supply their services to this changing pattern of demand. In the public sector there is a formal tradition of planning generated by statutory legal requirements. In the private sector, planning is motivated by competition and the need for profits and organisational stability. In both sectors planning will have concern with spatial organisation and the location of activities. Additionally, there will often be a problem of resource allocation over space. This is well-illustrated in local government, with the Rate Support Grant attempting to equalise local discrepancies between resources generated and perceived need, and in the National Health Service, where the RAWP formula for resource allocation attempts the same task. Again, methods of spatial analysis can contribute to these activities as we shall show in the next section.

(vi) Competition

Most private sector organisations face competition from rival companies. In the public sector competition as such is usually more limited, although there is inevitably competition for resources between different sectors and different regions. In many areas, spatial competition emerges as an important feature - for example, market share achieved within an area - say a postal district - compared with that of a company's competitors will be a crucial indicator. How is this then affected by a rival company opening a new store in a particular location? Methods of spatial analysis can begin to answer these types of question.

(vii) Distributional effects

The effects of government policies, of changing technology and methods of service provision are not the same across different sectors of society. It is important to understand the distribution of effects between different groups. For example, the move towards a retail system characterised by few large outlets will have significant dis-benefits for those with no access to a car and in areas where public transport provision is poor. In health care it is well known that there exist marked differences in the utilisation of services by social class. Geographical methods, notably microsimulation, which retain the appropriate levels of sectoral and spatial disaggregation can test the impacts of policies

and change on different groups.

The next step in the argument is to show how these issues are dealt with by modellers in the variety of situations outlined earlier.

4. EXAMPLES OF APPLICABILITY

4.1 Health care planning and analysis

The provision and utilisation of health care services in most Western countries demonstrates several significant spatial dimensions. There is the problem of resource allocation to health authorities in a country, and from health authorities to particular services at certain locations. On the utilisation side, the rate at which persons become in-patients, everything else being equal is a function of accessibility to facilities. Planning in the British National Health Service (NHS) is a relatively recent activity: a statutory requirement to publish a plan has existed only since 1974. Up till that time new developments came out of growth money, which averaged 4% per annum in real terms prior to 1974. Now the situation is very different. Resources are being cutback and redistributed away from over-funded regions in the South East to other areas and out of acute medicine into community care. Strategic and operational plans have to be prepared and updated on a regular basis, regional reviews of district performance take place annually, new management structures have been introduced and new systems for data capture are being developed. DHSS annually publishes performance indicators for each district and region so

facilitating measures of comparison and monitoring of progress towards objectives.

These developments have resulted in a requirement for analytical planning methods that allow health authorities to examine the potential impacts of various policies and the effects of exogeneous change (such as increases in the elderly population). In our work at Leeds, we have developed two distinct sets of models. The first is a regional strategic planning model (Clarke and Wilson, 1984) which is underpinned by a set of spatial interaction models that represent the flow of patients from residential areas to hospitals. The model has the following structure. For a base year, a detailed description of the health care system is provided. Variables included are:

age and sex distribution by residential district

hospitalisation rate by residential district, age and sex

cases by hospital by district and specialty

beds by hospital by district and specialty

case capacity by hospital by district and specialty

occupancy rate by hospital by district and specialty

average length of stay by hospital by district and specialty

cost per case by hospital by district and specialty

resource inputs by category, hospital and specialty

the flows of patients from residential district to hospital by specialty

a cost or distance matrix

Using this information it is possible to calculate for the base year a set of performance indicators and catchment populations and

also to calibrate the spatial interaction models. The model then requires the user to specify a description of the same system at some future point in time, say 5 or 10 years hence. This can be done by preparing a new data file or by editing the existing base file on-line, to input the changes (say in bed provision by specialty or projections of population change). A new patient flow matrix is calculated using the calibrated spatial interaction model and the new set of performance indicators and catchment populations calculated. Comparisons can then be made between these and the existing PIs to examine the effect of the change. It is then possible to change the plan on-line in light of the first model run and so on. All the results can be plotted on the PC display unit using colour graphic facilities. The model system has been applied in Piemonte (Italy) and Yorkshire RHA in England.

The district model is specified at a much finer level of disaggregation in terms of the characteristics of the patients and the services provided, and uses microsimulation methods (Clarke and Spowage, 1985). The model system consists of five main components. First, a model that generates the initial population for a spatial system of interest. This consists of lists of households and individuals, with an appropriate set of attributes (age, sex, marital status, race, location, SEG, etc) specified at the micro-level. A morbidity model generates a sub-population of individuals with medical conditions that require hospital care. At this stage source of admission and specialty of treatment are also determined for each member of this sub-population. An allocation model then

allocates demand to supply, by hospital, condition, residential location, specialty and so on. The allocation takes the form of a heuristic which reflects priorities and admission policies in the district. Un-met demand forms the waiting list for the next period of the simulation. On admission, a set of outcomes are determined for each patient - form of discharge, length of stay, operative procedures and so on. A cost accounting model assigns a cost to each case dependent on specialty and hospital. Finally, a demographic model updates the characteristics of the population for the next year of the simulation. The model is typically run for a ten year simulation period and a wide variety of policies can be tested. The model has been developed for Dewsbury District Health Authority in Yorkshire and used in a wide range of policy analysis. Collectively, the two models are being made available to health authorities in a package known as HIPS (Health Information and Planning System), which combines a capacity to analyse information on existing activity and utilisation together with what-if planning.

In addition to contributing to planning issues, models have an important role to play in understanding key relationships between the provision of health services and their utilisation. Utilisation shows significant spatial and social class variation, the former is related to accessibility to services, the latter correlated with resource constraints, lifestyle, diet and knowledge of service availability.

4.2 Education

Many education authorities have been hard hit by a combination of falling school rolls and a long-running squeeze on

expenditure. The problems are further complicated in many instances by a spatial redistribution of the population, for example, involving considerable population loss from inner city areas and corresponding growth in the suburbs. In many instances, these considerations lead to a need for a fundamental reappraisal of the existing system of schools' provision and, in suitable instances, to reorganisation. The tasks involved in this generate a need for skills in planning of an order not previously necessary in education administration. These are illustrated here by the case of Leeds: the planning task is complex and difficult and this provides an opportunity to show how the skills of the modern geographer and computer analyst can be brought to bear.

Leeds at present has a schools' system based on infant, middle and secondary schools (with a limited tertiary provision for those in the usual school age groups). At a time of falling rolls, difficulties arise because there are too many separate schools, some of which fall below an efficient minimum size. In particular, there are often severe problems at the sixth form end of the scale: the minimum size needed to facilitate the economic provision of a good range of A-level (for example) subjects is higher than can be achieved by many of the existing secondary schools. There is also a need to integrate the provision of advanced academic subjects with more vocational subjects. For these kinds of reasons, the Leeds Authority is now proposing a major reorganisation in which post-16 education will be based on a tertiary system. This in turn implies a complete reorganisation of lower levels with the present 5-9, 9-13

and the 13-16 part of the 13-18 system to be changed to 5-11 and 11-16 schools with a suitable tertiary upper tier. (And there is a further complication: there are still parts of the Leeds area which are organised on a primary-secondary basis).

The magnitude of the planning task involved can be easily seen by reference to the present numbers of schools in the Leeds Authority which are, approximately, as follows: 300 infants, 120 middle and 60 secondary. This implies something of the order of 500 sets of buildings. The planning task, therefore, is to make the best use of existing buildings to provide a reorganised schools' system which is both within budget and maximally effective in relation to a set of education performance indicators. Traditionally in educational administration, there are catchment areas for junior schools (and perhaps middle schools) though these kinds of boundaries break down in relation to secondary schools as parents exercise their freedom of choice of school. Even in the latter case, each school might have an informal catchment for planning purposes.

It is now possible to articulate the planning task: to devise alternative forms of provision - each alternative constituting a 'plan' - which meet all the education policy constraints. This involves manipulating a very large amount of information, in particular, the flows of pupils from each (finely specified) residential area to each school. To carry this out in detail for a wholesale reorganisation might involve (for the sake of a rough illustration) 300 x 300 = 90000 possible flows. Even if an initial approximation is used and only the residential areas 'near' to each

school are considered, then this might involve 300 x 30 = 9000 numbers. It is worth emphasising that for each plan, all relevant performance indicators have to be calculated. It may be possible to complete this calculation once or twice manually, but what is involved is the constant fine-tuning of such a system as the plan is updated and revised. This can only be done using a suitable computer-based analysis and planning system. Such experience has been gained in other sectors, both public (health, see 4.1 above) and private (retailing, for instance, see 4.4 below). This means that computer software is available which can be applied to education relatively easily.

There are four main elements to the analytical basis for a planning system, and then a fifth requirement which has to be met for effective planning. We first list these areas and then discuss each in turn: demand for school places by residential area; a specification of schools' provision (teachers, places, other resources); a procedure for estimating (for a compulsory 'catchment' system, a 'free choice system' (or anything 'in between') the allocation of pupils from residential areas to schools; a performance indicators package (which would include an analysis of the extent to which 'constraints' or 'standards' were satisfied; and, in relation to planning - interactive software to facilitate the continual refinement of plans - which would include good graphics output facilities. By extending the principles already outlined for health above, the modern geographer can offer such a system.

4.3 Financial services

The financial service sector is a dynamic and increasingly important feature of economic systems in developed countries, but has largely been ignored by geographical analysts. The sector includes traditional banking services, building societies, loan companies, credit and charge card companies, insurance, pension and share companies. There is a diverse variety of companies offering single and multiple products. Competition between them is intense and the rules of the game are changing continually, from the launch of new products and from government policy - building society deregulation, for example, now permits societies to offer unsecured loans and compete directly with banks. The response to change has been equally dramatic: building societies have embarked on a process of merging: the number of societies has reduced from 700 to 153 in the period 1960-86. Both building societies and banks are cutting down the number of branches to reduce costs and replacing them with Automatic Teller Machines (ATMs). Although the financial service industry encompasses elements from both retailing and service industries, it is unique in the form of its products, client relationships and distribution channels (Pinpoint Analysis Ltd, 1986).

Market research in the UK has shown that there is an enormous variation in the use and consumption of products in the financial services arena, sectorally and spatially, in the UK. This variation correlates well with census data indicators and it is possible to generate ACORN type profiles of small areas to categorise their financial service characteristics (eg FINPIN, Pinpoint Analysis Ltd,

1986).

Importantly the financial service area is one where there is high quality data. Every financial transaction is recorded automatically with the time, location, customer and transaction details captured. It is thus possible to build up in fine detail the activity patterns of different customers or the utilisation of different types of facilities. For most financial institutions these information sources remain a rich untapped vein of market information.

The possibilities for spatial analysis are great. Branch rationalisation will have important effects on customers and on employment. In 1986 there were 14,762 bank branches and 8748 ATMs in the UK. The latter will continue to grow at the former's expense. Banks and building societies will face major decisions as to where new ATMs are to be located (at approximately £30,000 per unit) and which branches will close. Additionally, given the variation in the spatial demand and utilisation of financial services, the launch of new products will require careful marketing using spatial discrimination methods.

4.4 Retailing

The last twenty-five years have witnessed the transformation of the British retail system. The shift on the supply side from corner shop and ribbon development shopping through the supermarket and district centre to the existing superstore and edge-of-town developments, has also been matched by changing consumer activity and technology. The growth of car ownership,

refrigeration and microwave technology have, in part, reduced dependence on local shops and daily purchasing, which can now be limited to weekly or even monthly main shopping trips. However, for the less privileged members of society, such as the elderly and those without access to a car, the benefits of change have not always been realised.

For the large retailers, the highly competitive nature of the existing system and the high levels of investment involved in opening a new store have persuaded a number of them to incorporate spatial location models in their planning process. Interestingly, models of retail trade and location date back to the early 1960s with the work of Huff (1962), Harris (1965) and Lakshmanan and Hansen (1965). Although these models have been used from time to time in Britain the lack of interaction data, which would give flows of customers from residential districts to all supermarket, store or centre destination prevented the models from achieving their full utility. Now, this interaction data is commercially available and it is therefore possible to calibrate and employ extended retail location models in a variety of important areas. For a retailer it is possible to review the performance of existing stores, determine profitable sites for new stores and to examine the impact of marketing and advertising. In this type of analysis the use of performance indicators is relevant in interpreting the output. For example, the market share a retail company achieves in each residential district of a region compared with that of its competitors is easily calculated from interaction data, either for the existing situation or to examine the effect of store opening or

closure.

From a local authority planning viewpoint, similar methods can be used to assess planning applications and to generate policies on zoning, say, in relation to accessibility to stores of different population sectors in different residential areas.

4.5 Utility industries

The utilities (gas, water and electricity) present an interesting combination of physical, resource and economic factors that can be mapped on to a spatial backcloth. We shall illustrate our discussion with reference to the water industry, although many of its features are shared by the other utilities. Water is unusual for the following reasons. First, the marginal cost of consumption to the user is zero, as a fixed price is paid for the ability to consume each year, while the marginal cost of supply is variable. Water has significantly variable unit costs, dependent on source, quality and distance transported. Secondly, while water authorities have to maintain minimum quality levels and guarantee supply they deal with inputs that are of variable quality and quantity. To reduce relevance on single sources of water, authorities typically develop a grid network system so that water can be moved from areas of excess supply to areas of excess demand.

The strategic planning and operational management of water services is now of increasing importance. The development of new sources, expansion of the network and the changing and growing demand for water in different areas presents particular problems. One concept that is useful in assisting network analysis is that of

value addedness. As water is treated and pumped value is added to it. It is possible, using detailed costing models, to estimate this value. A planning objective may be to minimise the total cost of water provision, subject to some minimum quality and safety standards. Spatial analytic methods, such as network optimisation and other mathematical programming techniques, can be used to assist in these planning exercises. This could be incorporated with an analysis of shifting demand for water by small areas, using, for example, microsimulation methods.

5. SOME PREREQUISITES AND POTENTIAL SPIN-OFFS

5.1 Introduction

For an applied human goegraphy based on modelling skills to emerge fully, a number of desirable developments are needed. We also feel that there are a number of possible spin-offs from an applicable human geography which reinforce the argument for the development of these prerequisites. The prerequisites relate to information, software, research laboratories and marketing and these are discussed in sections 5.2-5.5. The spin-offs are discussed in 5.6.

5.2 Information systems

We noted in section 2 that, in general, the range of information available to modellers has improved over the years. There are, however, some worrying trends. First, the present government has scrapped a number of government surveys as part of its overall reduction in funding of research into social and economic affairs in the country. Secondly, much useful information

is collected either by commercial market research organisations or is kept in-house by large institutions (eg banks). As Goddard and Openshaw (1987, this volume) point out, information is a commodity that has been 'privatised' - made accessible to those who can afford to purchase it. This implies two possible responses. One is that we have to seek partners to undertake interesting applied work, in other words to work directly with the data holders or those who can afford to purchase data for their own purposes. The other is that we have to be more ingenious in obtaining data, either directly or through the use of synthetic data generation methods, such as iterative proportional fitting (Birkin and Clarke, 1986).

5.3 Software

One explanation of why statistical analysis is more popular than mathematical modelling in geographical research may well be the wide availability of software packages for solving statistical problems. Packages such as SPSSX, SAS, and so on, allow the relatively inexperienced user to perform complex statistical analysis. Ignoring any potential concern with interpretation of results, there simply is no equivalent package for mathematical models. In another paper (Clarke and Openshaw, 1987) the importance of developing a modelling package (say, MPSS) has been argued. One point is that modelling style is supply not demand led, in that the availability of certain types of software is easily usable form encourages the adoption of techniques that are found in that software. For example, the spate of factor analytic studies of cities and regions in the early 1970s was probably generated as much

by the availability of software (SPSS) as by an inherent interest in the methodology. There is also a disincentive to write large amounts of code to solve relatively common problems, the software should be generally available, either as a package or a series of subroutine libraries.

5.4 Research laboratories

It is often pointed out that Britain lacks the equivalent of a Brookings Institute, where independent analysis of government policy and social and economic trends could be undertaken. Further, partly as a consequence of the system of local government, we have no regional planning institutes, unlike, for example, the Dutch, Swedes and Italians, where research into local planning and development is undertaken. The lack of these types of institutes, combined with the small size of the 'quantitative' parts of most university geography departments, means that there are few opportunities for the appropriate economies of scale to exist which allow for wide-ranging applied work to be done. The ESRC research initiative on Regional Research Laboratories, while to be welcomed, offers relatively small amounts of resources to be provided for each of the half dozen or so laboratories that are to be set up. As with the problem of obtaining information, collaboration, both between academic departments and with industry and commerce is needed if appropriate resources are to be brought to bear on the problem of undertaking applied work in the kinds of areas described in section 4.

5.5 The need for effective marketing

Amongst others, Batty (1979) has pointed out that

physicists obtain hundreds of millions of pounds of funding for research into phenomena that last considerably less than a millionth of a second. Scientists have clearly developed a persuasive line of argument that is taken seriously by government and funding agencies. Perhaps naturally quantitative geography is always going to have a more difficult job convincing governments and other agencies of the merits of its skills and subject matter. This may reflect the concern that government has in funding research on contemporary social and economic problems which, possibly, will show current policies in a poor light. It may also be a case of prejudice, for most people geography is still viewed as the subject they studied at school, perhaps several decades ago. Whatever the case, an effective marketing approach is required so that the contribution and potential of quantitative geography can be presented to those in government and industry.

5.6 Spin-offs

Although we have mainly focussed on the inputs in to an applicable human geography, it is worth mentioning some of the less readily apparent outputs. First, we can expect that a combined study of major elements of the socio-economic system (such as those discussed in section 4) at the regional or metropolitan level will significantly improve the understanding of, and information on, the area being examined. In turn this should lead to the development of a contemporary regional geography, based on both informed description and analysis. This would also facilitate links with alternative, radical, approaches. A second spin-off is that once

established a demonstrable concern with application will allow quantitative geography to move from a marginal to a more central role in human geography. As a contributor to debate about the changing society in which we live, the discipline of geography generally ought to be more relevant to issues of public concern. This, in no small way, may encourage both the recruitment of able students and increase their range of employment opportunities.

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