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EXPLORING DECISIONS IN PUBLIC POLICY MAKING: STRATEGIC ALLOCATION, INDIVIDUAL ALLOCATION, AND SIMULATION.

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CONTENTS:

1. Introduction

2. Planning to maximise life changes

3. A concern for effectiveness

4. Linear programming models requiring groups of units or persons

5. The aggregation problem

6. Micro-simulation models and local government interactions

7. Policy exploration combining macro- and micro-approaches

8. Conclusion

Acknowledgements

References

1. Introduction

An important problem in planning of public policy is how best to allocate scarce public resources to individuals in need of them. We are not so much concerned how to define need but instead with how to allocate resources once needs have been defined. We consider that this problem can be best approached in three related stages. Firstly, a strategic allocation of resources combined into services needs to be made in terms of broad categories of persons in need. Secondly, allocations of services to individuals most in need must be performed. Thirdly, the impacts of these allocations need to be considered over time and, if necessary, a revision made to the first two stages. We are essentially not only concerned with the outputs of allocation models but with their outcomes in terms of the lives of recipients and non-recipients. In addition, we seek to develop an approach that helps planners to explore through simulation the consequences of their decisions and to help them choose between a range of possible alternatives. In the past decade, urban and regional planners have faced many difficulties both in deciding alternative futures for society and charting society towards a selected future. Planning in the face of overwhelming uncertainty still retains a legitimacy if planning is considered to be appraisive and reasoned decision making leading to action: even if the action taken is the explicit decision not to intervene. Planning becomes knowing where one is at and where one hopes to go, and where one has departed from it and why, and, importantly, to encourage a consideration of alternatives before acting.

The view of the goal of planning that we adopt is not that planning should even seek to provide "the future" for people, but the planning should instead seek to provide greater opportunities for people to develop their own lives. Planning, then, ceases forever to claim to provide the rigid framework and instead becomes the helping hand.

We are particularly concerned with the role of local authorities in seeking to provide greater opportunities for people to manage their own lives. We are especially concerned with improving the effectiveness of local authority services; not only to increase or decrease desired outputs and resource deployment (such as, numbers of public sector houses built, or numbers of social workers employed) but also to consider outcomes,

that is, how these outputs or deployments affect the lives of recipients and non-recipients. We consider techniques whereby managers can evaluate the effects of policies and so seek to choose a mix of policies which maximises the effectiveness, as they measure this, of their policies. Our intention is to assist managers in the exploration of their explicit and implicit preferences in policy making.

A particular interest of ours is whether or not individuals (be they persons, firms, institutions, etc.) should be grouped together in policy analysis. In model building and application individuals have often in the past been grouped, for reasons outlined in Section 5. This has been done often with little respect to the appropriateness or otherwise of using an aggregate approach. We demonstrate that aggregating individuals into groups is neither the sole way of achieving the objective of a better allocation of resources or necessarily the best way. We outline a micro-simulation approach as a conceptual and practical tool for modelling urban systems and examining the effectiveness of local government services. Specifically, we attempt to show how the combined use of aggregate and disaggregate methods of analysis can provide new and interesting ways for exploring the consequences of policy decisions. Potentially, the methodology described is able to help planners address the problem of relating the allocations of resources to individuals to the strategic decisions which allocate the global sums of resources.

2. Planning to Maximise Life Chances

Why as urban and regional planners do we seek to manage urban systems? We seek to increase personal access to resources, to increase personal income and wealth in the wider sense of financial and non-financial resources (Townsend, 1979). More limited answers of the sort "to encourage the production and distribution of income and wealth" ignore the purppses of our actions. Underlying these actions is the assumption that income and wealth are resources with which individuals can attain a 'better' life. We are implying generally that at the margin more income and wealth mean better standards of living or increased 'welfare'. That is, increased welfare for some or all persons on whose behalf we are planning, sufficient to outweigh any decreases in welfare also caused. In this sense, income and wealth become surrogate indices of the achievements of our policies as planners.

Of course, the adoption or implication of a 'welfare approach' has been extensive in the past decade (eg. Harvey, 1973; Pahl, 1970; Philips and Walton, 1975; Williams, 1976; Grant, 1977; Ferguson and Munton, 1979). In applying such analyses the prescription of valued solutions to perceived problems involves the planner in both constraining and enhancing consumer sovereignty. Some consumers lose their ability to choose their manner of consumption, others may gain by being now able to choose. Planning, thus, is about enhancing or denying the freedom of action of individuals by changing allocations of resources (Lundqvist, 1978).

Hagerstrand (1975) considered eight constraints restricting the freedom of individual action:

(i) the indivisibility of human beings, and of many other entities, living and non-living,

(ii) the limited length of human life and of many other entities, living and non-living,

(iii) the limited ability of the human being and other entities to take part in more than one task at a time,

(iv) the fact that every task has a duration,

(v) the fact that every movement between points in space consumes time,

(vi) the limited packing capacity of space,

(vii) the limited outer size of terrestrial space,

(viii) the fact that every situation is inevitably rooted in past situations.

Hagerstrand's constraints can be extended to include those of insufficient resources and the adjustment of human expectations to insufficiency of resources. The latter constraint may need explanation. This is the constraint of 'relative deprivation' (eg. Runciman, 1966; Inglehart, 1977). Briefly, we can assume that satisfaction with a given aspect of life is determined by the size of the gap between one's perceptions of one's current situation and one's level of aspirations. Aspirations will tend to adjust to a person's circumstances. A person will either aspire to more or less of the same thing or may change the importance given to that

particular aspect of his or her life. For example, a person unsuccessful in the job market may either, or both, lower his or her criteria of an appropriate job or/and deem gaining a job to be a lesser priority.

Constraints on the freedom of individual lives such as those outlined may be considered to have at least three consequences. Firstly, the need for *choice* is implied. If we can not do everything we must be careful to do what we most want subject to not huring others in their similar pursuit. With limited resources, choice implies foregoing some opportunities to achieve others. Every choice can be measured therefore in terms of opportunities foregone or opportunity costs. Choice is as important in the future as in the present; we need to keep open as many potentially useful options as practical.

The second consequence is that of the relevance of *need* rather than demand. Demand can be considered to be expressed need, that is need expressed at the price of opportunity costs. But not all need which is felt by an individual may be expressed, nor may persons deemed in need when compared 'objectively' to others feel themselves to be in need (Bradshaw, 1972; Forder, 1974). Thirdly, there is the consequence of the pertinence of the welfare stance in planning which considers the welfare of at least all groups and properly of each person, across the *range* of life's opportunities. Domains of opportunities of course include such aspects as employment, housing, leisure and family life. This is not to argue that planning as intervention is necessarily the proper or best arbiter of all the life chances for individuals. More,it is to recognise that human beings are varyingly indivisible across the domains of life and that as planners, an awareness of the effects of the *urban system* upon human beings is essential. Aspects of one domain need to be set within the full context of the domain, and the domain and its aspects need to be considered along with other domains. For example, provision of day care facilities for elderly physically handicapped persons needs to be set within the full context of personal social services provisions, and both set within the provisions of all services and other resources and lives affected. Otherwise, how are we to assess the success of our provisions?

The danger inherent in our above discussion is that of semantic argument. As Bennett and Chorley (1978) appreciated, systems can be recognised at all scales of magnitude and with all degrees of complexity. If we consider a system to be a structured set of objects and/or attributes

the urban system is how we see it as planners, and largely what we see as relevant to include. For example, we may consider that employment, educational services, housing services and social services are relevant topics for inclusion. We may also add to this transportation and health care. We may choose to distinguish between the tiers of local government, or we may not. In addition it is possible to consider whether we treat individuals as units (eg. persons, households, firms, etc.) or as classes, that is groupings of units. As is argued in Section 5 this choice of aggregation is central to model building. Of course, the hierarchy composed of domains which we discussed above is similarly defined by ourselves. As planners our criteria of what to include in our system of interest is properly relevant to our task, and so our current task needs clearly to be stated: in general, it is to consider models relevant to practice and which maximise individual life chances. We are interested particularly in the role of local government in this process. In this sense we are interest in *corporate* and *community* planning and not land use planning alone (eg. Stewart, 1971; Eddison, 1975).

3. A Concern for Effectiveness

Whilst the objective of the public services planner is the enhancement of life chances through the enforcement or influencing of patterns of consumption, the appraisal of costs and benefits is often the appropriate method of working. This is not to say that a single social welfare function can be maximised but rather that costs and benefits are to be assessed across a range of programmes, of indicators of performance and/or recipients (or groups of recipients) through space and time, subject to resource constraints. The objective is to maximise net social benefit, social benefit less social cost, on the basis of appraisal. From the outset we recognise the general impracticability of specifying a social welfare function of the classic sort.

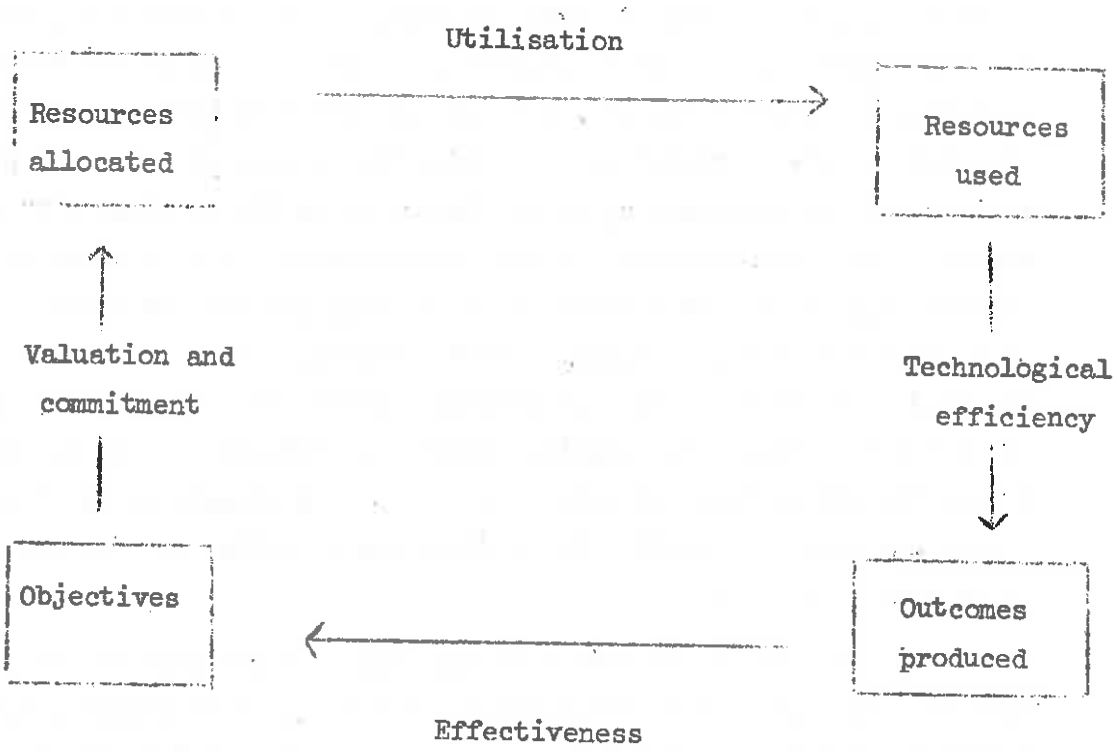
The problems of attempting to define aggregate welfare functions are well known in economics where similar difficulties are faced when, for example, a suitable aggregation scheme is needed in defining macro-level consumption and production functions. Aggregation problems are varied but usually relate to the aggregation of information or theories of behaviour over individual units into clases or groups. Typically, once aggregation has been performed then it proves difficult to recreate

the original micro-level specification. Economists have wrestled with these problems for some time (Green, 1964) and because of the lack of a satisfactory outcome the debate continues (see the papers in Harcourt (1977). A discussion of aggregation in public policy analysis is continued in Orcutt *et al.* (1976) and Clarke, Keys and Williams (1980). In practice the planner often lacks information about how his policies affect peoples' lives, he lacks assurance of who should be grouped with whom. That is, if it is necessary to group people at all, an argument which we pursue later.

The organisational response to maximising welfare by its provisions is properly threefold. Firstly, unlike the concept of consumer valuation alone of services, local government services are often provided upon an argument as to who needs them. This argument involves a consideration of who *ought* to receive resources in preference to someone else, for resources are limited and needs are different. Organisational valuation firstly needs to be made explicit therefore. Secondly, the planner needs to consider what in local government is termed efficiency or "cost" minimisation ("cost" in the private and financial sense); how to use limited resources to accomplish a specified service in the most economical manner (Calvert, 1980). Thirdly, the effectiveness of services must be considered: that is, how, and how far, intervention achieves or detracts from the authority's purpose, (Prentice, 1979). The explicit statement of value and the consideration of efficiency and effectiveness are the organisational corollary to the welfare economists' concept of "efficiency", the maximisation of net social benefit or consumer surplus (eg. Morgan and Morgan, 1972; Coelho and Wilson, 1976; le Grand and Robinson, 1976). To avoid confusion it is perhaps appropriate to use the term 'technological efficiency' for the particular local government usage. Technological efficiency and effectiveness are of course two sides of the same coin, and are not independent of values. In practice, values enter into technological efficiency as constraints and into effectiveness as objectives. Similarly, values are not independent of technological efficiency and effectiveness. This dependence is illustrated in Figure 1.

In the 1970's local government was substantially concerned with performance review rather than with policy review, that is, more with technological efficiency than with effectiveness. With the recent movement toward *policy planning* and *policy analysis* in local government (eg. Noad and Friend, 1977; Bains, 1978) and firm "cash limits" and

Figure 1. Dependence of attributes in appraising performance



(after Calvert (1980)).

capital controls imposed by central government (H.M. Treasury, 1980) more attention in the future is likely to be placed upon considering effectiveness (Prentice, 1980a). Scarcity of resources will likely enforce a consideration of surrogate indices of effectiveness, rather than of effectiveness *per se* (prentice, 1980b). Instead of directly measuring the success of, say, a local authoritiy's mortage policy in encouraging owner occupation of housing the planner may more readily use indices such as the numbers of applications initially processed and the number of inspections made. A fuller consideration of effectiveness would instead require an interpretation of the significance of these measures (see Holroyd and Owens, 1971). Considerations would include probabilities of gaining other loans and the characteristics of persons receiving and not receiving funds from possible sources, including the local authority. A real discrimination may also be a measure of success or of failure. Topics such as this are ideally suited for modelling by micro-simulation as we outline below.

The concept of effectiveness usefully directs our attention towards structured dissaggregation of services. For example, 'housing services' is properly recognised as a series of outputs: it is neither a unitary service or directly measurable by the ratio of households to houses. For example, the Housing Services Department of one London borough council contributes to the following services or programmes:

Allocation of council dwellings
Management of council dwellings
Aid to the homeless
Purchase of miscellaneous dwellings
Rent rebates
Rent allowances
Housing advice
Tenant/landlord relations
Loans for house purchase
Residential caravan sites
Building council dwellings
Maintenance of council dwellings
Improvement of purpose built council dwellings
Improvement of environment and ancillary facilities of council dwellings

Improvement of miscellaneous dwellings
(London Borough of Greenwich, 1978).

The concept of disaggregated but structured services is applicable across all local authority services, and this can be attained by the design and production of a corporate statement of programmes. In modelling, however, the number of programmes and of the indices measuring the effectiveness of these programmes will usually have to be restricted if individual recipients and non-recipients are grouped because of problems of measurement and dimensionality. To these we return, and suggest an alternative approach.

Our method involves the consideration of various techniques to maximise valued effectiveness. We do not assume a mangerial environment of certainty of values, of information or groupings of persons as potential or existing recipients of services. Instead our methods may be termed "guided soul-searching", "adjointed incrementalism" or "normative satisficing" (Baum and Carson, 1974; Marschak, 1975; Zionts and Wallenius, 1976). Essentially, we assume the planner to be both an explorer and an educator, who explores the preference structures and constraints of his authority's elected members and fellow officers. Whilst a satisfactory solution is sought, the first satisfactory solution is not necessarily accepted. Instead a better solution is incrementally sought (Prentice, 1977). The models we discuss can be used to this purpose. Solutions are suggested as profiles of services across client groups or across clients. Managers, be they elected members, officers, or others, can respond to their preferences and seek a further series of solutions. And so the process continues until we arrive at an acceptable solution.

At a basic level the provision of alternative policies can be seen as normative satisficing. The production of a corporate plan describing a programme and forming the basis for changes in programmes is a more developed form of this method. We wish now, however, to review more abstract models applicable to normative satisficing: models which either require groupings of individuals or consideration of individuals as units or persons/households.

What we seek to show is that while it is feasible to disaggregate these models to include a wide number of attributes, there are alternative ways of handling this disaggregation, which are described in

Sections 6 and 7. These methods, employing micro-simulation techniques have a number of advantages, in particular it is possible to handle a large set of attributes pertaining to client groups without the concomitant massive increase in computer storage requirements associated with disaggregating macro-type models. Further, it is shown that in certain cases the approach we propose, that of using relatively coarse aggregate (or strategic) allocation models coupled with micro-level individual allocation models is equivalent to using a very highly disaggregated (and in essence impractical) strategic allocation model.

4. Linear Programming Models Requiring Groupings of Units or Persons

Linear programming models as exploratory tools have been developed or proposed in health and social services and provide us with useful examples for discussion. Linear programming models have the well known limitation of requiring both a linear objective function and linear constraints and also the practical assumptions of transferable resources and a rapid change of individuals as clients so enabling adjustment to the optimal allocation. Whilst it may be possible to produce a "grand design" maximising effectiveness this is of little practical use if most of the current allocation of resources is fixed into the medium if not long-term: fixed either in terms of individual recipients or type of recipient. Rapid change is rarely the case in important local government services such as public housing and personal social services. Once into the system a recipient may stay put for years, even decades. In such situations it is appropriate to look at the margins of provision, where change can be effected. Bayat, *et al.* (1975) for example, proposed a linear programming model in which they sought directly to maximise effectiveness. The model required ideal service profiles or "preferred levels" of services and discrete client groups. The model also included valuations of services as applied to 'client' groups and valuations of the importance of each resource type in meeting the needs of each group of clients. This is a measure of effectiveness, therefore. The model assumed that no synergetic effect existed between resources; for example, that the provision of both meals-on-wheels and home-helps to a group of clients is equally effective in meeting their needs as the sum of the values assigned to these individual resources if applied separately. This is a limiting assumption for services are clearly not evaluated separately by social workers but as packages.

Although not formally defined in the original article, the Bayatt et al. can be interpreted as:

$$\underset{\{\underline{T}\}}{\text{Maximise}} \quad Z = \sum_i \sum_j E_{ji} F_i \frac{T_{ji}}{H_{ji}}$$

subject to

$$\Sigma T_{ji} c_{ji} < b_j$$

$$\sum_j b_j = B$$

$$\sum_j E_{ji} = 1.0 \text{ for each } i$$

$$\sum_i F_i = 1.0$$

where i is a group of clients

j is a group of resources

E_{ji} is the effectiveness of resource j in meeting the needs of group i

F_i is the weight given to group i

T_{ji} is the actual allocation of resources j to client group i (an output)

H_{ji} is the perceived need of resource j by client group i (an output)

c_{ji} is the unit cost of providing resource j to client group i

b_j is the given availability of resource j in money units

B is the total departmental budget.

Thus the model attempts to maximise effectiveness and by meeting the demand for resources (H_{ji}) in a way consistent with budget constraints.

The model can be extended to the case where resources are to be weighted, say, to imply the use of existing or more easily developed resources:

$$\underset{\{\underline{T}\}}{\text{Maximise}} \quad Z = \sum_{ij} E_{ji} F_i \frac{T_{ji}}{H_{ji}} G_j$$

subject to one further constraint

$$\sum_j G_j = 1.0$$

where

G_j is the weight given to resource j.

It would be possible to extend this model to constrain the amount of resources allocated to any particular client group for example:

$$\sum_j T_{ji} c_{ji} \leq L_i$$

where L_i is the maximum amount of resources allocated to group i. This constraint, though not included in the Bayat model may be important, if, for example, planners wished to put a ceiling on the resources allocated to old persons living with relatives.

As cited the Bayat model does not define alternative packages of services for client groups, but instead achieves an allocation of resources which maximised valued effectiveness by moving resources between client groups. This is the limitation of the assumption of no synergetic effect. To include these effects necessarily means considering non-linearities; in practical terms these make the models much more difficult to solve. Also, the model requires the definition of discrete client groups. Consultancy by researchers seeking to use the Bayat model at Durham University Business School has shown that one client classification proceeds beyond single attributes such as elderly persons, physically handicapped persons and family problems, limitations of records imply a limited sample size and the variety of human conditions imply many groups of small numbers of clients with consequent problems for linear programming models, (Nelson, 1979). In addition, discrete client groups are required for the measurement of the effectiveness of provisions. However, are individual clients or their familites more appropriate units to consider? How do personal, family or community circumstances vary in access to resources? If in attempting to measure effectiveness we find that all physically handicapped persons, for example, cannot be grouped together because secondary characteristics (such as access to resources or personal problems other than physical handicap) vary significantly, either we abandon our

attempt to include an effectiveness measure in the model or we increase the number of client groups, or we adopt an alternative approach as we discuss later.

The problems of cost minimisation and the non-synergetic assumption are solved in an alternative model of MacDonald *et al.* (1974) for 'balancing' health provision. Discrete client groups are still required, however, and effectiveness is 'inferred'. However, the size of the objective function implied by this model imposes a practical limitation upon its general usefulness to local government.

In the MacDonald *et al.* model, alternative forms and standards of care were derived after consultations with teams of medical, nursing and social work advisors. The 'forms' of care were defined not in terms such as 'good' or 'bad' but as the amount of each service received by patients each week. The developed model relates to three possible ways of adapting plans to the scarcity of resources; by treating patients less intensively; by treating patients in different ways; and by treating fewer patients (Boldy and Russell, 1977).

In the original publication of the model by MacDonald *et al.*, the modelling team had not decided upon groups of children, but had defined 16 surgical client groups of children, 10 maternity groups, 2 client groups of general practitioners, 34 groups of elderly persons, 24 groups of mentally handicapped persons and 36 groups of physically handicapped persons. The future sizes of these groups were extrapolated in proportion to population trends.

A preliminary 'balance of care' model is as follows:

$$\text{Minimise:} \quad \underset{\{X_{il}\}}{} \quad \sum_k C_k \sum_i \sum_l U_{ilk} X_{il}$$

$$\text{Subject to:} \quad \sum_l X_{il} = D_i \quad \text{for all } i,$$

$$\sum_i \sum_l U_{ilk} X_{il} \leq B_k \quad \text{for all } k,$$

Where,

i	is a group of patients,
l	is an alternative set of resources uses per patient,
k	is a resource,
X_{il}	is the number of patients from group i to be allocated alternative l,
C_k	is the given unit cost of resource k,
U_{ilk}	is the given use of resource k per patient for group i under alternative l,
D_i	is the given case-load in group i,
B_k	is the given availability of resource k.

That is, the model seeks to find the allocation of groups of patients to alternative sets of resources which minimises cost, subject to given case-loads, and resources. It is assumed in using the model that as the definitions of alternative service packages were derived in consultation with relevant professionals, they are reasonable packages.

The model is extended to an explicit 'inferred worth' model as follows:

$$\underset{\{\underline{X}\}}{\text{Maximise}} \quad \sum_i g_i d_i - \sum_i \sum_l \sum_k C_k U_{ilk} x_{il}$$

Subject to the constraints,

$$\sum_l x_{il} - d_i = 0 \text{ for each } i,$$

$$\sum_i \sum_l U_{ilk} x_{il} < B_{Nk} \text{ for each } k,$$

$$D_{Li} < d_i < D_{Ui} \text{ for each } i,$$

Where,

d_i	=	number of patients in group i receiving care,
B_{Nk}	=	resources available,
g_i	=	weighting of group i,
D_{Li} and D_{Ui}	=	lower and upper bounds on the demand from patients in group i.

That is, the number of patients receiving care is now a variable, and instead of relying solely on constraints saying that some patients must be treated, this model gives a contribution to the overall inferred worth from each group of patients, providing an incentive to treat this group of patients. MacDonald *et al.* define net inferred worth in abstract as,

> "...Net inferred worth is a utility function exclusive of cost, which is implicitly defined by the prevailing trends in the average amount of care given to each patient and the types of categories of patient cared for". (MacDonald *et al.*, 1974, p. 267).

Simply put, one looks at current practice. The model is further extended to a third formulation to accept ideal service levels and different allocations of resources.

> "The inferred worth must be defined so that acceptable allocations U_{ilk} of resources to each patient are optimum when resources are unconstrained". (MacDonald *et al.*, 1974, p. 268).

The concept of inferred worth is also described by Canvin and Walker (1976). "Average, ideal or desired standards of care" are defined for services to client groups and the contribution to the total inferred worth from treating one patient at ideal resources, even if circumstances allowed otherwise, since the extra contribution to the inferred worth would be outweighted by the negative contribution of resource cost. MacDonald *et al.* defined the following as the complete inferred worth model:

Choose the d_i, x_{il}, and U_{ilk} to maximise

$$\sum_i g_i d_i + \sum_i \sum_l \sum_k h_{ilk} U_{ilk} - \sum_i \sum_l \sum_k C_k U_{ilk} x_{il}$$

Subject to the constraints:

$$\sum_i x_{il} - d_i = 0 \text{ for all } i,$$

$$\sum_i \sum_l U_{ilk} x_{il} < B_{Nk} \text{ for all } k,$$

$$D_{Li} < d_i < D_{Ui} \text{ for all } i,$$

$$U_{Lik} < u_{ilk} < U_{Uilk} \text{ for all } i, l, k,$$

Where,

h_{ilk} = the weighting for each patient of devoting U_{ilk} units of resource k to each patient in category i receiving treatment l.

In this full model, not only do client groups have values, so do the applied services, a behaviourably more realistic model than the earlier models described by MacDonald *et al.*

The concept of inferred worth is similar to that of Drewnowski (1974) and Adelman *et al.* (1975) in deriving the importance of policies from the implicit social aims of their makers. This is the technique of "revealed social preferences" or "social judgement" from statements of intent or of actions. However, just as Drewnowski assumes that plans are formulated on the bases of social aims, MacDonald *et al.* assume that sets of resources are preferred on the sole basis of the success and ways in which they achieve medical aims. Scarcity of resources and restricted knowledge do not significantly affect this allocation.

The need to produce discrete client groups both to avoid double counting of individuals and to measure the effectiveness of resources is compounded if we week to extend models of this kind to an urban system: as our domains of attention increase so do our difficulties of classification. For example, not only do we have the problem of the 'bus user who is also at times a pedestrian and car passenger, but also that of the same person also needing to be classified by employment, housing tenure and leisure interests, for example. In a similar manner the measurement of effectiveness or inferred worth can be avoided by failing to include these in a model and instead responding to the decision maker's reactions by solely altering the constraints and objective functions. This was the method of Jenkins (1972) who reported a model for maternity services planning. The model was bounded by the following constraints:

1. The consumption of financial resources.
2. The consumption of physical resources.
3. The attainment of specified aims of the organisation.
4. The attainment of general political, social or economic aims.

Jenkins included aims as constraints or as successive objective functions. "The attainment of specifiable aims of the organisation" in terms of maternity service provision for example became a constraint, "the infant mortality rate must not exceed...". Similar "the desire to have as many women as possible having their babies delivered in hospitals rather than at home" (as one social aim) could be defined as the objective function for part of the linear programme.

Jenkins suggested that the minimisation of costs should be selected as the first objective function, and minimum targets were used to set the constraints. Initially, this model is similar of course to that of MacDonald *et al.*; the principal difference is in the type of constraints. Cost minimisation was used as the objective function with aims defined as constraints and the aim of the managers then applied successively as objective functions. The modeller therefore changes the objectives from efficiency to effectiveness. The Jenkins model applies of course to only one client group. When extended to several groups the problem of classification returns.

While the types of strategic allocation models discussed above address one aspect of allocation in local government services, they ignore an equally important aspect, that of individual allocation. This is particularly important in housing and social services where priorities are determined in terms of perceived need, for example who is to be allocated the council housing that has just been vacated, or a place in residential care? However, the multi-faceted nature of needs - as say, expressed in personal disability or housing characteristics - gives rise to a high dimensional classification and ordering scheme. We outline a procedure for integrating strategic and individual allocation methods in Section 7.

Except when successive constraints and objective functions are included all these models are ahistorical. Lacking is an account of how people fare historically as resource allocations change. In practice, therefore, for reasons outlined above, linear programming models will only be able to consider a limited amount of heterogeneity in the system of interest, i.e. only a few groups of individuals with little or no (gross) measure of effectiveness (other than interaction with decision makers preferring one output to another).

5. The Aggregation Problem

In the evaluation of planning policy traditional concern has rested with the definition of aggregate classes or groups such as the elderly or physically handicapped, as outlined above. In this section we wish to demonstrate that the variety of problems associated with these aggregate methods have serious implications for evaluating investment possibilities. In Section 6 we outline an alternative, micro-level approach which, when used *in conjunction with* macro-level methods offers the potential for planners to consider the choices and constraints that face individuals and households, and thus some measure of the effectiveness of policies. The approach will allow us to measure need in terms of individuals' attributes. Further, the micro approach not only allows us to project need but may enable us to simulate the effect of current policies on future need. Also it may allow the outcomes of different alternative policies to be assessed and perhaps ranked in terms of desirability or effectiveness. Such an approach is entirely compatible with the notion of freedom of action outlined earlier.

As discussed in Section 3 a number of problems are involved when attempting to classify groups by multiple attributes. Not only do the number of classes rapidly increase with the number of attributes considered but also many of these classes will have no occupants. When programming models of the kind described above are used in such situations the solution time of the models is increased and they may be intractable*. Yet, for many socio-economic phenomena and related policy issues, several inter-related attributes have to be specified if a significant amount of variability between individuals is to be accounted for (eg. Orcutt *et al.*, 1977). Failure to pick up this heterogeneity has been a constant source of criticism. For example, elderly persons are not at all alike either in handicaps or helpful neighbours.

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* Solution time of programming problems generally increases in proportion to the square of the number of variables in the constraint set.

More formally we can consider the aggregation problem as being confronted at a variety of stages in the modelling process, as outlined in Figure 2, and these will be considered in turn before outlining our micro-analytical approach.

PROCESS	ISSUES
Representation	Micro-level or Macro-level units?
Mathematical Statement	Does this embody micro- or macro- theory?
Calibration/Estimation	Prior to or after aggregation is micro-level data available?
Model Solution	What data is available?
Model Output	Micro-level output? Aggregate output?
Evaluation	Identify individuals or classes?

Figure 2: Aggregation issues in the modelling process.

It is worth stressing that each planning question implies its own level of aggregation. For certain questions, for example short term population forecasting, a highly disaggregate approach may prove unnecessary. Further we may wish to consider different levels of aggregation if we are concerned with prediction as opposed to explanation (Green, 1977). For example, prediction of the aggregate level of service utilisation may be derived from a coarse regression equation, but this would tell us little or nothing about why this percentage arises. In certain cases the lack of appropriate methodologies and/or data bases for certain levels of aggregation

(or disaggregation) may *a priori* exclude a, (perhaps appropriate) style of analysis.

One further warning is necessary. Politicians may well use aggregation as a means of political expediency, to disguise the impact of policy decisions (eg. who wins and who loses). Thus the promotion of disaggregate methods of policy analysis is not automatically guaranteed a welcome.

We now discuss the issues pertaining to aggregation in the six stages of the modelling approach outlined in Figure 2.

(i) Representation

In any modelling exercise we must ask how are the component parts of our system to be represented? Do we concentrate on individual units of decision making - individuals, households, firms, banks, etc., or aggregate these units into classes, such as the elderly, or the household sector, industrial sectors, etc.? Often this decision is constrained by the information available to the modeller, at other times the type of problem being investigated and the types of techniques available prejudge the issue (Clarke, Keys and Williams, 1980).

The choice of an appropriate representation may in turn largely determine the aggregation issues in the subsequent parts of the modelling exercise.

(ii) Mathematical Statement

Once an appropriate form of representation has been determined then it is necessary to relate functional dependencies between the variables of the system in the form of some mathematical statement. It is within these functional relationships that any theoretical statements will be embodied. This theory will pertain to the units or groups that are being represented. Thus at the smallest unit level the modeller may employ theories that relate to individual behaviour, such as choice, while at the macro-level the theory employed will necessarily be of an aggregate nature. Of course, there may be no theoretical content in the mathematical statements, instead merely accounting relationships or empirical regularities.

(iii) Calibration/Estimation

Whether the estimation of model parameters should be performed using disaggregated micro-data or at different levels of aggregation has been the subject of protracted debate in econometrics. Orcutt, Watts and Edwards (1967) found that models estimated from micro-data will give generally superior forecasts. This is at variance with Grunfield and Griliches (1960) findings that aggregation of economic variables reduced specification errors associated with micro-data. It should be noted that the difficulty of generalising these statements to all types of models argues for the aggregation issue to be viewed in relation to the specific application of a model.

(iv) Model Solution

The type of solution method adopted will be determined partly by (a) the representation used and (b) the system of equations defined. As we discuss later, there may be no precise analytical way of solving a system of equations and approximation techniques, such as simulation, may have to be used. While the method of solution is not particularly an aggregation issue, often quite different types of approaches will be used depending on whether a micro- or macro- representation has been adopted.

(v) Model Output

If the model which has been used is specified at the micro-level (that of individual decision making) then the modelloer or policy analyst has the ability to output either micro-level information or to aggregate the information in any particular way he chooses. For example, while he may consider it necessary to perform model operations on micro-units he may not necessarily be interested in micro-level outputs. Unfortunately, this choice is not available if the model is specified using group aggregates. Briefly, a modeller cannot get any more information out of a model than he puts in, for models essentially *transform* information.

(vi) Evaluation

In Section 1 we argued that planning was about enhancing or denying individuals' freedom of action by changing allocations of resources. Evaluation of alternative policy options thus either involves the identification of those individuals that suffer or benefit from a certain policy, how much they suffer and benefit and how much this costs, or enumerating the number of people who benefit and suffer by certain amounts and at what cost. The former approach is only possible through a micro-specification, the latter is a possibility of either a micro- or macro-specification.

It should be apparent by now that the aggregation issue has an important role to play in the modelling process. In addition it will not have escaped the reader's notice that the majority of modelling exercises in planning and policy analysis have opted for an aggregate approach. In the next section we outline an explicitly micro-level approach that can be used in conjunction with complementary macro-models, such as the resource allocation models outlined earlier. We identify two separate aspects of the modelling procedure - allocation and dynamics. Allocation of resources in local government services is seen as a two stage process, strategic allocation and the allocation of resources to individuals.

6. A Micro-Simulation Model of Local Government Interactions

In the previous two sections we have pointed out firstly that aggregation plays an important role in the model building process and that certain aggregate approaches leave much to be desired, especially when interdependencies within systems and the interrelationship between an individual unit and its environment are of interest. We now outline an approach based on *micro-simulation* that appears to be a particularly flexible one for the study over time of a wide range of issues pertaining to local government in general and service provision and consumption in particular.

Micro-simulation is not a new technique, its earliest application in socio-economic systems is due to Orcutt *et al.* (1961). Orcutt and his colleagues, rejecting conventional forms of

economic analysis as being insensitive and over simplified, had the ambitious task of attempting to model the U.S. economy using micro-simulation. However, their earliest efforts were limited to a study of household dynamics, but more recently, working at the Urban Institute in Washington, Orcutt's team have considerably widened their scope and have looked at the effects of various welfare programmes at a national level (Orcutt *et al.* 1976). An example of a specific urban and regional application is given in Clarke, Keys and Williams (1979), who have developed a model of labour and housing systems for Yorkshire and Humberside. Here, we only outline the basic principles of the method, before giving details of the local authority applications.

The cornerstone of micro-simulation lies in the specification of the system of interest at the smallest unit level. For the household sector we may consider individuals, $\underline{I}$, with m associated attributes or characteristics, which may be specified according to the problem at hand, living in households, j, with a further set of l attributes, $\underline{k}$. We may thus identify with a household, H_j, the following list:

$$\{I_j^{\underline{1m}}, I_j^{\underline{2m}}, \ldots, I_j^{\underline{nm}}, k^j, k_2^j, \ldots, k_1^j\}$$

where n refers to the number of individuals in the j^{th} household. The type of attributes, $\underline{m}$, and $\underline{k}$, that are considered will depend partly on the interests of the modeller and also on the information available. Typical individual attributes may be age, sex, marital status, income and occupation type. Household attributes may consist of summary characteristics of the individuals in the household such as household size, household income, as well as, say, housing tenure characteristics, whether the household has access to a car, etc.

It may be noted that this approach allows for the retention of a high degree of information relating to actors in the system, a feature we argued was necessary for many socio-economic phenomena in the last section. Further, this approach allows for the efficient manipulation of information, again often a difficulty with aggregate approaches to multiply classified individuals*.

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* For a much more thorough discussion of these two points see Clarke, Keys and Williams (1980).

The intial population (sample) required for this type of specification may either be obtained from a survey or, when this is not possible, by synthetic methods, as outlined by McFadden *et al.* (1977), using joint probability matrices that produce a population consistent with known information.

Once a population sample has been established the next task is to specify the system of equations that will determine the transformations on this intial population. The equations will again reflect the nature of the modelling exercise as well as the theories of behaviour invoked. In addition models of other sectors may be constructed, and the relationships between these sectors and the household sector determined. For example, a model concerned with urban labour and housing markets may typically require forecasts of labour and housing demand and supply and these may be provided by a regional econometric model. In the exaple presented below we show how it is possible to construct a model of the local government sector and its interactions with individuals and households.

The solution of the set of equations is in most cases intractable using precise analytical methods and it is necessary therefore to resort to simulation techniques. One such method, Monte Carlo sampling has been used extensively by micro-modellers (eg. Orcutt, *et al.*, 1976; Kain and Apagar, 1977; Clarke, Keys and Williams, 1979). This simply involves the comparison of a random number, $r(0 < r < 1)$, and a conditional probability, p, for a *transition* between states (eg. a person dying). The transition only occurs (and other transitions possibly induced) if r is less than or equal to p. The *association* of units, say households to dwelling units, workers to jobs, may be undertaken in a similar manner and matching algorithms usefully employed. Several alternative algorithms are available to perform this task. Typically, they involve an aggregate matching of classes and then Monte Carlo sampling to select appropriate individuals and jobs or houses.

Micro-analytic simulation models have been used in a variety of applications in different fields. The work of Orcutt and his colleagues as noted above, has been concerned with the dynamics of households and the derivation of income, with particular attention on the assessment of service and welfare programmes at federal

government level. Kain *et al.* (1978) have analysed the effect of housing allowances on the metropolitan housing system, employing micro-simulation techniques in their most recent version of their model.

For our particular interests we may identify several interactions that we are concerned with. These are shown for a metropolitan district or outer London Borough in Figure 3. We now proceed to discuss how we represent the various actors in this system and account for their inter-relationships.

(i) Households and Individuals

Individuals and their constituent households clearly form a major component of the urban system and in terms of the local authority they are the major consumers of services provided and, in turn, contribute to local authority revenue by paying rates and charges for certain services, in particular public sector housing. In addition, individuals may be employed by the local authority, which can be the biggest single employment sector in an area*. In accord with the representation outlined above we consider the individual within a household context and the following attributes can be considered as important for representing local authority relationships with individuals' housing and employment choices.

Individuals Characteristic	notation
age	I_j^{n1}
sex	I_j^{n2}
marital status	I_j^{n3}
educational attainment	I_j^{n4}
occupation type	I_j^{n5}
employment type	I_j^{n6}
wage	I_j^{n7}
other income	I_j^{n8}

* Leeds Metropolitan District employs 13% of the total workforce

service consumption	I_j^{n9}
etc.	I_j^{nm}

Households characteristic	notation
age of head	k_1^j
sex of head	k_2^j
marital status of head	k_3^j
household size	k_4^j
number of children	k_5^j
tenure of house	k_6^j
housing type - tenure and sector	k_7^j
housing expenditure	k_8^j
expenditure on rates	k_9^j
expenditure on L.A. services - by type	k_{10}^j
other expenditure	k_{11}^j
total household income	k_{12}^j
number of members of household in employment	k_{13}^j
spatial location	k_{14}^j

Indices on disabilities and "support" can be included for similar social services applications.

Of course the actual list of attributes will depend on the application being undertaken. Certain problems will inevitably arise relating to acquiring information. These may be more acute for the research worker outside a local authority than one within local government. However, the worker in a certain sector of an authority may find difficulties in gaining data from other departments!

(ii) Local Authority

A local authority may be considered as consisting of a number of separate departments variously, independently and jointly providing a series of services structured in some hierarchic manner (Prentice, 1979). Each department or sector will have a number of identifiable attributes such as:

Number of employees, by occupation type

Expenditure on capital and revenue items

Revenue from different sources

Types and levels of service provisions.

Specific departments will be identified by attributes appropriate to their activities. For example the modeller may wish to include the following attributes in relation to the management of council housing by a housing department:

Number of dwellings by age and type

Number of households on waiting list by type

Rents of different types of dwelling

Maintenance costs by type of dwelling

Vacancy index by type of dwelling and size of dwelling.

In addition, each local authority as a whole, will have attributes, not only aggregates of sector characteristics but factors such as the rateable value, rate poundage levied, interest rates, subsidies, etc. We can represent these attributes in a parallel manner to the individual and household sector, i.e.:

$$L\{S_k(\underline{c}), \ldots, k = 1, s, : (\underline{d})\}$$

where L refers to the local authority; S_k to sectors, k, of the local authority; $\underline{c}$, the vector of attributes of sector k; $\underline{d}$, the vector of attributes of the local authority, and s the number of sectors in the authority.

A series of acounting relations will hold between local authority variables, particularly financial ones, eg. for a district authority:

Revenue required from rates = Total expenditure
- income from R.S.G.
- net trading revenue
- rental income from housing
- specific grants
- precepts of other authorities
- funds taken from reserves.

As the rateable value can be estimated the required rate poundage may be calculated once other incomes are known. Similarly it would prove possible to enumerate the physical and socio-economic indicators required for the Rate Support Grant calculations from the household and individual records in conjunction with some local authority information. These may give the local authority some indication of likely funding from the R.S.G.

(iii) The Economy

The way in which the economy develops, both at a local and national scale, will be both a response to, and have repercussions for, central and local policy initiatives. In turn the local labour and housing markets will partly be a reflection of local and national economic conditions. Macro-economic forecasting models have seen extensive development at the national level (see for example, the Treasury model, the Cambridge Economic Policy Group·), but regional or metropolitan models are less common (with the exception of Leontief style input-output models). Forecasts of level of metropolitan economic activity may be derived by applying regional multipliers to national forecasts, along the lines of Keogh and Elias (1979), or by constructing a local econometric model. Typically, the former approach of applying regional multipliers will be adopted, if only because of information constraints preventing the latter being feasible.

The next step in the procedure is to account for the dynamics of and inter-relationships between the 'actors' in our system, some of which are outlined in Figure 3. We may classify these in the following way:

(i)	Local authority	↔	individual/household
(ii)	Local authority	↔	local authority
(iii)	Individual/household	↔	individual/household
(iv)	Local authority	↔	individual/household
(v)	Economy	↔	individual/household
(vi)	Local authority	↔	central government
(vii)	Central government	↔	individual/household.

Let us illustrate these interactions, and how they may be handled within our framework, with the aid of two examples.

(a) A Reduction in Local Authority Manpower

Assume that a local authority decides it must make certain economies and will do so by a cutback in local authority employment, and for the sake of argument all these redundancies will occur in the social services sector. What are the effects?

(i) The number of employees in the service sector is reduced, as is the total number employed by the local authority. The relevant employment attributes thus change. Reductions in employment imply reductions in expenditure, and the appropriate value of those attributes will be recalculated.

(ii) The employment attributes of those workers made redundant will change, in the first instance from employed by the local authority to unemployed. Those individuals will now enter the labour demand pool. The individual's and concomitantly the household's income will change. The individuals may receive a variety of state benefits, eg. unemployment benefit, social security, which will be a cost to the Exchequer as may be other transfer payments that the household now becomes eligibel for. This change in income may effect consumption patterns, in particular it may influence the household's ability to compete in the housing market.

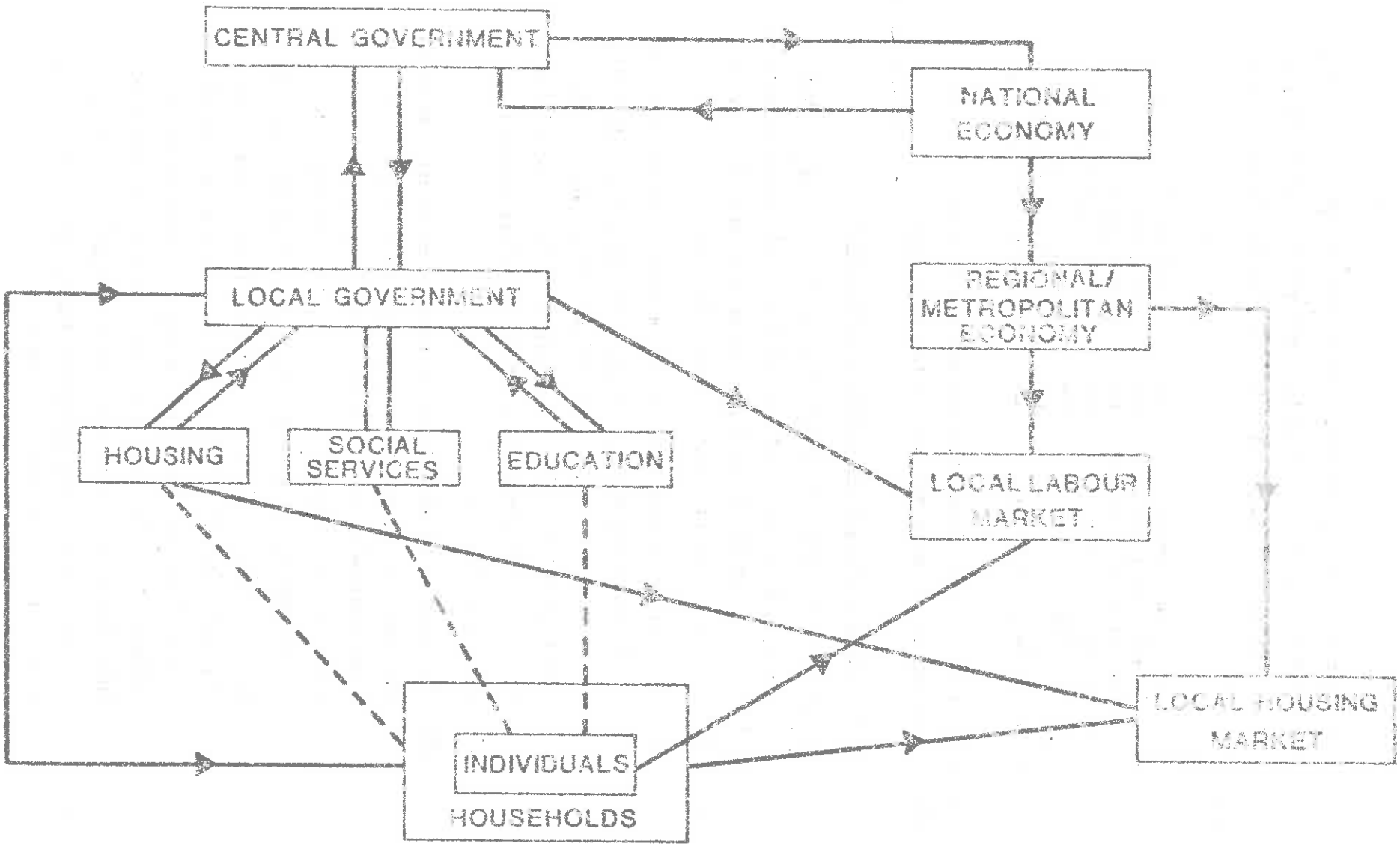

Fig 3 Some Government/economy/individual interactions

(iii) Any reduction in service provision that arises from the reduction in manpower may affect the availability of, and hence accessibility to, services for individuals and households within the system. For example, if a suburban social service centre was closed then new spatial accessibility indices could be calculated for individuals affected by the closure, as we know the location of households, and the location of other social service centres. If home helps are withdrawn in the reduction of employment, elderly persons may either become ill or die, their fires unlit and houses uncleaned. Or they may become eligible for other local authority social services such as residential accommodation. Either outcome is a cost to the public purse as well as to the individual.

(iv) There will be a variety of "second-round" effects less easily managed within this modelling framework. These include, for example, the reduction in consumption noted above and the effects this has on the final demand sector of the economy; assuming the person made redundant was a married male then there may be a trigger for his wife to attempt to find employment to supplement the household income. The withdrawal of home helps may cause a greater number of elderly persons to become dependent upon their children or hospitals, so reducing the earnings capability of the latter.

(b) The Selling of Public Sector Housing

The financial and social arguments surrounding the sale of public sector housing have aroused much passionate political debate in recent years, as well as researched appraisals (eg. N.A.P., 1979; D.O.E., 1980a). The Housing Act 1980 contains the right of most local authority tenants to purchase their house or flat. Some of the interactions that arise from a council house sale can be outlined as follows.

(i) The stock of public sector housing by type and location of dwelling is reduced, so the appropriate housing sector attributes will change. The local authority receives a sum of money for the house and thus will be credited to the Housing Revenue Account. A reduction in management/maintenance costs and subsidy receipts will also arise. Part of the net monies received will be available to supplement capital expenditure not just within the new house building programme (D.O.E., 1979, 1980b).

(ii) A household will purchase the property and this will involve a change in tenure attributes and almost certainly a change in housing financial characteristics.

(iii) Individuals/households in public sector housing or in the queue for public sector housing may find that their mobility within or access to housing is eroded, because of the reduction in stock. Much will depend upon who buys, what they buy and the characteristics of those on the waiting list. For example if mainly three bedroom 'cottages' are sold to tenants in their thirties and forties these houses would likely have become vacant only in twenty, perhaps forty years time. If the waiting list of the authority is mainly old age pensioners, three bedroom houses are hardly appropriate dwellings for them, even if they would have been available earlier. Appropriate measures of effects, such as council house waiting lists or transfer requests may be devised. From these and other indicators the effects of the council's policy may be viewed and their effectiveness assessed.

The two examples briefly illustrate the scope of the approach in the assessment of local authority policy. We now present in the next section as example of policy analysis using both the type of programming model outlined in Section 4, in conjunction with the micro-simulation models discussed in this section.

7. Policy Exploration Combining Macro- and Micro-Approaches

In Section 4, the use of programming techniques for the strategic allocation of resources in local government services was outlined. It was illustrated from social services that once we begin to attempt to disaggregate client groups by their attributes or to measure effectiveness of service provision the problem rapidly increases in dimensionality and concomitantly becomes much more difficult to solve. A possible alternative is to use both aggregate and disaggregate models which, in conjunction, can help not only to alleviate the problem of including a large set of attributes but can also help the policy-maker to explore the consequences of his or her decisions and preference structures. That is, both allocations to individuals and the effects of these allocations over time can be explored.

In this section we describe the main features of the method, using as our main example the provision of services for the elderly but also outlining that it could be used in examining public housing investment.

Focussing on services for the elderly we can for illustration distinguish eight different types of care,1.

1	Care types
1.	hospital
2.	residential homes
3.	sheltered accommodation
4.	sheltered accommodation with home help
5.	sheltered accommodation with home help and meals-on-wheels
6.	own home
7.	own home with home help
8.	own home with home help and meals-on-wheels.

In so doing for simplicity, we are assuming that c l erally require single resources, or at most, three resources each. For example

k	Resources
1.	Hospital
2.	Residential homes
3.	Sheltered accommodation
4.	Own home*
5.	Home help
6.	Meals-on-wheels

We also make the assumption (again falsely of course over much of England and Wales) that all the services are provided both by a single Authority and a single department. Simply stated, the initial problem may be idealised as follows. Allocate a fixed amount of resources between the eight types of service so as to maximise the effectiveness of the department in meeting the needs of the elderly. This, however, is only the first stage of the problem. Secondly, those clients who are to be allocated resources, or who are to experience a change in the level or type of service must be identified. Thirdly, the effects of this two-fold allocation procedure must be assessed over time and the allocations revised if necessary.

The first part of this scheme involves the solution of a programming model. Any consideration of refined grouping for clients or of service effectiveness is left to the second part of the method, if necessary to be inferred from the decision-maker's behaviour. Our programming model becomes more easily manageable, and may be of the Jenkins type outlined above, although in practice we may wish to move towards programming models that attempt to include non-linearities in their formulation. Initially, we are

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* Own home is included as a resource costing nothing to the local authority, but which is of great importance in caring for persons. Similar resources would include helpful neighbours and voluntary services.

interested in cost minimisation as a surrogate for effectiveness. Our constraints include, of course, level or service and resource availability. The preliminary objective function of the 'balance of care' model is employed initially, but for 'patients' we read 'elderly persons', of course.

$$\text{Minimise:} \quad \underset{\{X_{il}\}}{} \quad \sum_k C_k \sum_i \sum_l U_{ilk} X_{il}$$

$$\text{subject to:} \quad \sum_l X_{il} = D_i \text{ for all } i,$$

$$\sum_i \sum_l U_{ilk} X_{il} < B_k \text{ for all } \underline{k},$$

where

i	is a group of elderly persons,
l	is an alternative set of resource uses per elderly person, i.e. care type,
k	is a resource; for example, sheltered accommodation,
X_{il}	is the number of elderly persons from group i to be allocated alternative l,
C_k	is the given unit cost of resource k,
U_{ilk}	is the given use of resource k per elderly person in group i under alternative l,
D_i	is the given case-load in group i,
B_k	is the given availability of resource k.

Grouping of elderly persons for this part of the model is coarsely achieved by allocation to the following groups on the basis of main problem or handicap alone:

1	Group
1.	Completely dependent elderly (including psycho-geriatrics)
2.	Elderly blind or partially sighted
3.	Elderly with impaired hearing
4.	Elderly unable to bathe unaided
5.	Elderly unable to use the toilet unaided
6.	Elderly unable to clean their house unaided
7.	Elderly unable to go out of their house unaided
8.	Elderly unable to cook adequately unaided
9.	Elderly with relationship, enviromental or financial problems
10.	Frail elderly
11.	Other elderly.

The resulting allocation becomes a basis for discussion with the decision makers, and we enter the second part of our method.

Council housing investment can be approached in a similar manner. For example, in Wales, the Welsh Office requires local housing authorities to propose investment in housing under the following headings (Prentice, 1980) which we may consider as services:

New council house building

Slum clearance

Council house improvement

Acquisitions from the private sector

Improvement grants for the private sector

Mortgages for the private sector.

These services can be thought of as variously providing alternative forms of 'care' for persons requiring housing. These persons can be coarsely grouped by some of the pertinent characteristics already discussed, such as income, age, housing tenure. A preliminary allocation of resources then is made in the manner similar to that for elderly persons.

Whilst we have discussed programming models as the basis for the first part of this method, this has been in an attempt to demonstrate possible 'best' practice. There is no need to derive an allocation in this manner. Indeed, if many individuals cannot be deprived of resources they are already consuming and new recipients are to be few in number, programming models may be inappropriate. Models to look at fewer services or at the margins of services (that is, at those parts of services which may be reallocated) may alternatively be used as a basis for part two of our technique. Readers are referred to Mooney (1978) as an alternative to programming, based on appraising current recipients of resources and drawing up future decision rules to exclude or include recipients.

We now wish to move from strategic allocation of resources, combined into care packages, to the allocation of care packages to individual clients. For this purpose we require an output from the model outlined above, for example using our illustrative example the following allocation may have resulted for a client population of 1000.

Client types	Care types							
	1	2	3	4	5	6	7	8
1	35	5						
2		5						25
3		15					35	
4					40	100		
5								170
6				80				40
7					50			20
8								140
9							10	
10			50					160
11	10					10		

TABLE 1. Hypothetical Allocation Outcome

The large number of zeros recorded in this allocation arises due to the nature of the linear programming problem, which only allows as many non-zero elements in the matrix as there are constraints. In practice it is more than likely that we would observe greater dispersion of client groups across care types because secondary criteria as well as primary criteria are a cause for resource allocation. One improvement here would be to extend the programming model to include an explicit 'inferred worth' model as suggested earlier, or to move towards non-linear programming formulations.

The allocation of individuals to care types can now proceed. We perform this on the following basis. Given that there are a fixed number of certain person type to be allocated to a number of different care types we need to differentiate on the bases of extra attributes which individuals go where. This may be done as follows. Assume we have a list of all the appropriate individuals and information relating to their relevant attributes, along the lines suggested in Section 6 (we must of course have at least some data of this kind, otherwise we would not be able to identify appropriate categories). For example, part of the list might look like this:

Individual's name	Age	Sex	Marital status	Household status	Health status	Disability status	etc.
Mrs. X	82	F	Widowed	1	5	4	
Miss Y	77	F	Single	2	3	5	
⋮							

where the list of attributes included would be relevant to the probelm at hand. This list could be expressed formally as:

$$I_1^{11}, I_1^{12}, \ldots, I_1^{1M}$$

$$I_2^{11}, I_2^{12}, \ldots, I_2^{1M}$$

$$I_1^{21}, I_1^{22}, \ldots, I_1^{2M}$$

$$I_j^{n1}, I_j^{n2}, \ldots, I_j^{nM}$$

where I_j^{nM} refers to the value of the M^{th} attribute for the nth person in the j^{th} household on the list.

The planner, in attempting to distinguish which individuals should be allocated to given care types needs to measure the extent of individual's disparate needs and attach weights to these needs for each care package. Essentially, the perceived need will relate to the individual's attributes. These disparate needs must be combined in some way to provide a composite measure of the extent of a person's needs relative to others so to enable discrimination in the allocation of care. An index of need takes the following general form, for individual n,

$$(\text{Index of need})_j^n = \alpha_1 I_j^{n1} + \alpha_2 I_j^{n2} + \ldots \alpha_M I_j^{nM}$$

shere $\alpha_1, \ldots \alpha_n$ are a set of "weights" that are related to attributes I. Or, alternatively, the planner may attempt to use the preference structure of the decison-maker in judgement about the allocation (- these judgements are likely to be made from 'experience'). In either case a subset of individuals from the original set is chosen to be allocated to a certain care package. This procedure is continued for all care packages and clients in the population.

So far we have not invoked any form of micro-simulation model. We have merely performed a two-stage allocation procedure based, firstly, on a set of group aggregates, secondly, on a list of individuals characterised by a set of attributes. It is when we come to consider the dynamics of the system that the micro-simulation method becomes useful.

The next step in the argument is to try to explore the effects over time of the two-fold allocation scheme. We are interested in looking, perhaps over a five (and ten) year time horizon at what happens to both those who were allocated services, and those who were deprived, and perhaps also the way in which resources are consumed over that period. To do this we employ the micro-simulation approach outlined in Section 6.

There are a number of ways in which the simulation method may prove of use. Firstly, independent of the allocation procedure, a forecast of future need for service packages may be estimated from the changes in the number of persons characterised by certain attributes. More pertinently, simulation over time enables the planner to obtain some estimate of how the allocation of current resources will affect the life chances (well-being) of the persons allocated resources or denied resources. The probability of an individual surviving in a certain condition may be dependent on the care type received or not received and, providing appropriate medical information on these transition rates was available, this type of effect could be incorporated into the simulation model. Thirdly, the planner is able to investigate the pre-emption effect of allocating resources to clients in the immediate terms but to the expense of likely future clients who may have to queue. For example, once a place in a residential home or sheltered accommodation is provided, this form of care is rarely removed during the person's life unless a more appropriate form of care becomes available. The models will also indicate the long-term revenue implications of new capital investment; for example, old age persons' homes have to be staffed, heated and otherwise maintained. This would not of course apply to all services, social work, home help and to a lesser extent meals-on-wheels services can be varied in their frequency of provision to elderly persons.

Conceptually, the possible combinations of different types of policy exploration are outlined in figure 4. We conceive of three potentially interesting areas in which the planner can use the model framework outlined so far. Firstly, the weightings of groups (such as g_i in the 'inferred worth' model) can be adjusted, as it is unlikely that any real concensus as to the value of these weights will exist amongst officers and elected members. Not only may a different resource allocation arise from this adjustment, it may also be able to derive information as to the relative sensitivity of each of the weights in relation to the allocation. Using the same set of attribute weights, $\underline{a}$, the consequences in terms of which individuals are allocated to which care package can also be explored, and the dynamics investigated through simulation. Alternatively,

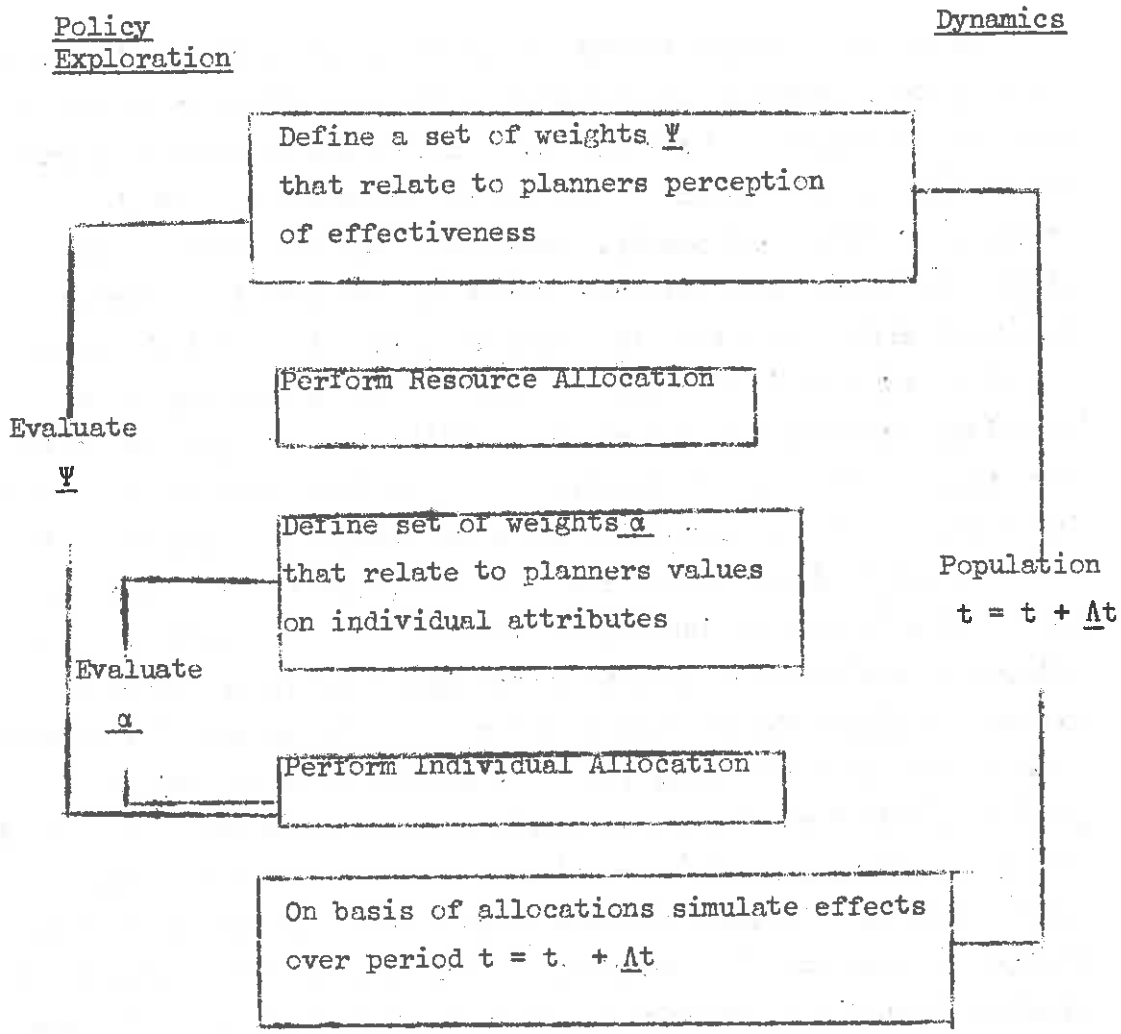

Figure 4. The iterative cycle of policy exploration

and the second use of the method, the same sort of sensitivity analysis could be performed on the attribute weights, $\underline{a}$, under constant or varying group weights, $\underline{b}$.

What this policy exploration is allowing is the definition of a space in which many (but not necessarily all) of the possible alternative outcomes exist. The planner can, therefore, relate the weights or preferences he uses to the outcomes that he desires or wants to avoid. The third use of the approach lies therefore in informing the planner how his judgements and allocation of resources may have implications for the system of interest in the future. This may be in terms of qualitative information, such as the identification of a "bottleneck" in queuing problems or information that indicates that certain rules or investment decisions that are being made now should be revised in the light of likely future behaviour. It may also be in terms of more precise information that, for example, suggests that an increase in provision of a certain resource substantially improves the quality of life for a group of individuals.

While the approach that we have outlined has been developed for a particular example we believe that many different problems in planning have a similar structure, and by resorting to this kind of framework the planner may gain useful insights into the consequences of policy making. The case for not using the dual method of allocation arises only when every different combination of relevant attributes is included in the categorisation for the strategic allocation and the planner is thus indifferent to any individual attributes not included. This is also the only condition when aggregation of individual attribute weightings would correspond with group weightings.

This approach to policy analysis does not guarantee that a 'best' solution to a set of problems can be found. The promises of, say, dynamical programming or optimal control theory therefore are not contained within this approach. We do believe however that as an alternative to these very technically complicated methods, which have yet to be demonstrated to have usefulness for local authority planning, the approach does have the potential to allow decision makers to explore the consequences of their decisions. This is seen as an essential part of any planning process.

One problem in applying such techniques as those described in this section is not the inherent weaknesses of the models themselves, but rather of the lack of data. Public organisations rarely collate data in the form needed for either stage in the process. Service delivery and persons known to be served by the organisation are generally unrelated in aggregate records. Service review generally takes the following form, exampled respectively from a Dyfed county council plan:

> "Shortfall has not been quantified in relation to the number of elderly people who would require sheltered accommodation".

and

> "In comparison with Welsh Office guidelines show that Dyfed is 224 places short of the recommended figure" (Parfitt, 1978).

In contrast, models of the type discussed in this paper require data which often needs either to be collated from non-computerised records or to be collected by a survey, as recently undertaken for disabled persons in Torfaen (Hunt and Hoges, 1980) or for social work clients in Durham (Nelson, 1979). However, progress towards computer-based records in social services may aid the provision of appropriate data, depending of course, on the systems employed. Other services, such as housing, will still have to rely, of course, on survey data, as many in 'need' do not report to the local authority.

If it is thought worth while pursuing the task of implementing the sorts of models outlined in this paper then a move towards collecting information in an appropriate manner and the design of information systems may be seen as a fairly high priority for planners.

8. Conclusion

The approach outlined in this paper is aimed to help the planner in at least two ways. Firstly to explore the consequences of his decisions, that is, appraise the potential alternatives that may exist at a certain point in time under certain conditions. No attempt is made at saying that the single best alternative can be found by adopting a model based approach, more that a range of alternatives can be defined and that the process of picking whatever is considered to be the most suitable of a set of alternatives lies firmly in the hands of the decision maker. Secondly, to allow a significant number of attributes to be included in any allocation mechanism. Again, it should be stressed that the approach described above does not attempt to find an optimal solution to the allocation problem when the additional attributes are considered, indeed we described the very restrictive conditions under which the list procedure is equivalent to an aggregate allocation using programming techniques. We are of the opinion that to search for an optimal solution to the sorts of problems that have been described in this paper is misguided because of the subjective nature of ranking the needs of one group against another, or comparing the needs of one individual with the needs of someone else. What is important and remains a viable goal is the necessity to be aware of what planners can or cannot do in a given situation. If the approach described here enables the planner to be more conscious of the fact that a set of alternatives typically exist for a certain planning problem and that associated with each alternative is a different outcome for the individuals concerned, then a useful purpose has been served.

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