PROOF OF CONCEPT FOR A DYNAMIC SIMULATION MODEL OF THE UK POPULATION

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1. Background and Objectives

The objective of the project is to build a dynamic model of the UK population which is richly specified and spatially disaggregate. In other words, both individuals and households are represented in great detail, being accorded characteristics such as age, income, family membership, and health status; and are assigned to geographical locations at least to the level of census output areas (i.e. more than 200,000 possible locations).

The work which is described in this paper forms part of the Moses node of the National Centre for e-Social Science. The Moses project[1] stands to benefit from e-Science technologies in a number of ways. In particular, the simulation model will draw on diverse, virtualised data sources; it will deploy models which are richly specified and therefore computationally intensive; and it will provide outputs to a community of researchers and policy-makers who will in all probability be spatially distributed.

However the main interest of this paper is directed towards simulation modelling rather than e-Science *per se*. This paper discusses the modelling technologies which are appropriate for building such a model (in Section 2) and outlines preliminary steps towards the implementation of the model (Section 3). Some of the most important problems and issues are reviewed in the concluding remarks.

2. Microsimulation Models for Social Science

Microsimulation has been defined as "a statistical procedure for estimating the characteristics of individuals from knowledge of the aggregate characteristics of the population to which they belong" (Johnston, 2000). A detailed review of the literature on microsimulation has been undertaken by Wu (2006). The review reveals that microsimulation provides a powerful approach in modelling social science which has a particular importance in public policy modelling studies. It has been widely used in a range of application domains (including, but by no means limited to, tax, pensions, health and transport) and major developments of microsimulation models have been experienced all over the world in the past decades.

Nevertheless, we also see microsimulation as limited in a number of respects. From a practical perspective, the models are intensive with regard to both data and computational resources. Both of these deficiencies can potentially be ameliorated through the application of e-Science technologies. Methodologically, this technique also has significant limitations for the current application. In particular,

[1] MOSES = **Mo**delling and **S**imulation for **e-S**ocial Science

microsimulation is predicated on the notion of individual entities which are either self-contained or interact only weakly with one another and with the environment in which they are situated. Such interactions are handled much more effectively within the emerging frameworks of multi-agent systems (MAS). We contend, therefore, that some kind of hybridisation between microsimulation and MAS is required to deliver the outputs from this project.

3. Moses Proof of Concept

The first stage towards the development of a national demographic simulation and forecasting tool is the instantiation of a ‘toy model’. In simple terms, the objective of the toy model is to include such detail only as is needed to demonstrate the utility and general principles behind the modelling approach.

The spatial extent of the toy model is confined to the city of Leeds, which is treated as a closed system. Within the city, individual people and household groups are assigned to precise individual locations. The starting point of the simulation is a base population of individuals within each census output area. The objectives of the simulation are now twofold: in the first place, a process of household formation, through which individuals are combined into household and family structures. Secondly, a process of household dynamics, through which households are aged, fragment and dissolve.

The process of household formation is shown in the form of a flow diagram as Figure 1. Note that what is represented here is a static or synthetic process: we are trying to estimate the relationships between individuals within households within a baseline population; rather than, for example, modelling dynamic processes by which single individuals choose their partners, marry and have families.

Sample results from the household formation process are shown at Table 1. One of the objectives of the simulation at this point is to ‘find’ a spouse for each of the Household Representative Persons (HRP) within the base population. Ideally, therefore, we expect the number of households formed (right hand column) to match the number of HRPs (left-hand column). Although the rate of household formation approaches 100% in some cases, this is never achieved in any of the examples shown in Table 1, and in some cases as many as 20% of households are unformed. At the time of writing, this problem appears to be attributable to a lack of ‘spouse candidates’ within the base population. Steps are therefore in process to regenerate the base population to allow a more satisfactory set of households to be created.

The dynamics of household change are shown in Figure 2. At this stage, we are particularly conscious of the important impacts of changing household structures on health care services. Thus we have a particular interest in changing health status over time, and the idea that as one partner within an elderly couple becomes infirm, then one or both household members may move from independence into care. As this model becomes more sophisticated, we hope to represent more complex interactions, such as the importance of local service provision, and even the strength of both social and family networks within the care process. At this stage, however, the toy model is a much more stylistic and simplified proof of concept. Households and their members are allowed to age, dissolve, and die without being regenerated through new household formation. Therefore as the model is run forward over time, the populations within each area gradually wither and disappear (see Figure 3). In areas with a relatively elderly demographic structure – such as FL39 and FY72 – the rate of decline is much swifter than in younger areas such as FA37 and FC23.

4. Next steps

The methods and results discussed within this abstract reflect early stages in establishing a proof of concept for a dynamic simulation model with policy applications. It is clear that further refinements to the model, and greater articulation of the underlying assumptions is urgently needed, and it is our intention to report on such developments within the full paper. Further to satisfactory proof of concept within the extended model, we will be in a position to consider deployment of the models at a national scale within the context of real policy problems.

References

RJ Johnston (2000) Microsimulation, in RJ Johnston, D Gregory, G Pratt, M Watts (eds) *The Dictionary of Human Geography*, Blackwell, Oxford.

B Wu (2006) Developing and validating an agent based geographical decision support system for the planning of the next generation in UK: a Literature Review, mimeo, School of Geography, University of Leeds.

Table 1.

Population Structure by OA

OA	Total	HRP	non-HRP	children	singleNonHRP Adults(include Elderly)	marriedNonHRP Adults(include elderly)	Household Formed
					spouse candidates		
00DAFA0037	221	114	107	19	80	8	96
00DAFA0001	304	143	161	59	95	7	132
00DAFC0023	229	94	135	50	77	8	77
00DAFD0028	296	139	157	55	90	12	122
00DAFH0070	298	154	144	68	73	3	98
00DAFK0075	326	114	212	94	104	14	110
00DAFR0058	310	128	182	46	117	19	119
00DAFL0039	309	122	187	58	113	16	114
00DAFS0065	245	103	142	49	85	8	97
00DAFX0025	319	117	202	64	128	10	115
00DAGA0053	221	101	120	50	56	14	78
00DAGC0012	253	129	124	50	69	5	101

Figure 1.

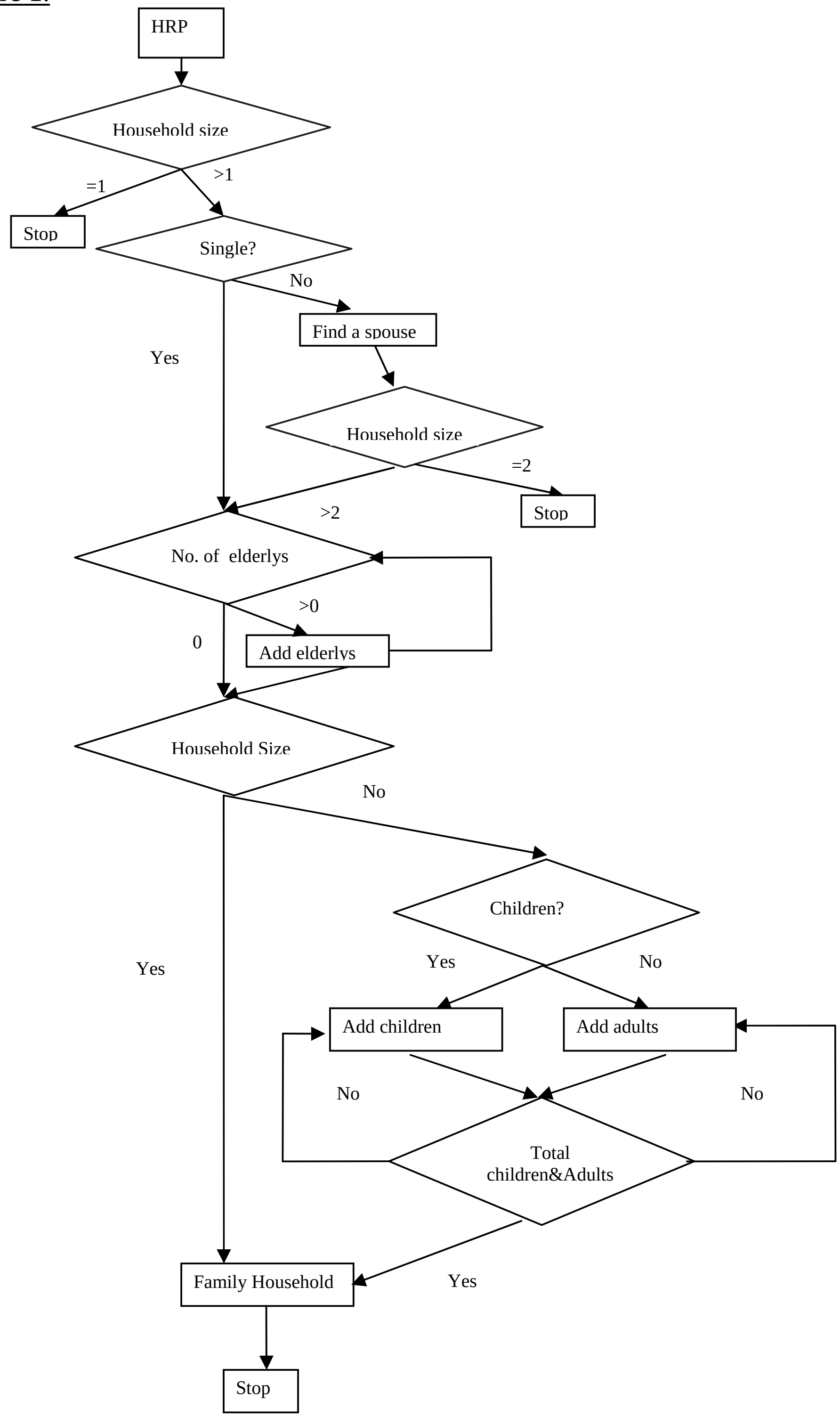
HRP
Household size
=1
>1
Stop
Single?
No
Find a spouse
Yes
Household size
=2
>2
Stop
No. of elderlys
>0
0
Add elderlys
Household Size
No
Children?
Yes
Yes
No
Add children
Add adults
No
No
Total
children&Adults
Family Household
Yes
Stop

Figure 2.

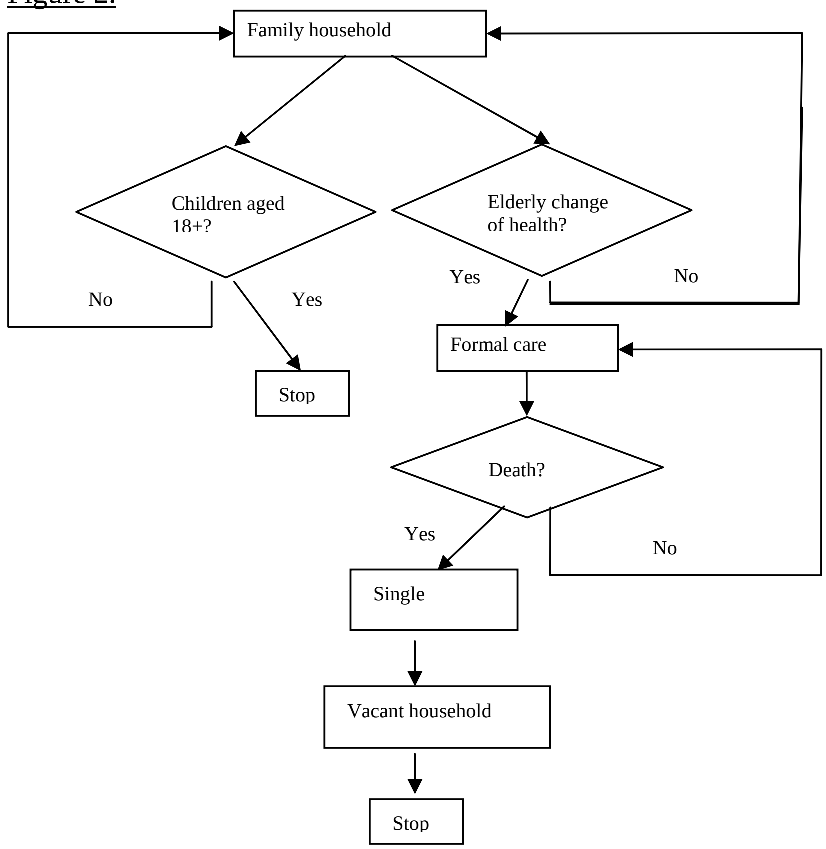

Figure 3