Internal Migration in the United Kingdom: An analysis of scale and zonation effects

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1. Introduction

Population redistribution through internal migration is an important and ubiquitous global phenomenon. The magnitude, intensity and spatial pattern of internal migration in any country depends on the size and shape of the areas for which data are collected. Over 6.2 million people changed their place of usual residence in the United Kingdom (UK) in the 12 months before the 2001 Census, for example, whereas the annual level of migration between local authority districts over the 2000s fluctuated between 2.7 and 3 million.

In this paper, we will use software developed as part of the IMAGE (Internal Migration Around the GlobE) project (http://www.gpem.uq.edu.au/image) to examine what effect changes in the spatial scale (number of areas) and spatial pattern (configuration of areas) can have on a different migration indicators in the UK. The IMAGE studio (Stillwell *et al.*, in press) allows the computation of a suite of local and global indicators, including the mean distance migrated and the distance decay parameter calibrated using a doubly constrained spatial interaction model which provides a measure of the frictional effect of distance on migration. Rather than using the studio to compare internal migration between countries (Bell *et al.*, in press), the aim of this paper is to compare different streams of migration using the same set of 406 areas, called Basic Spatial Units (BSUs), which are used for local government administration and central government resource allocation across the UK. Initially, we introduce the studio before showing some initial modelling results based on aggregate UK flow data.

2. The IMAGE studio

The IMAGE studio is organized as a set of four subsystems: (i) the data preparation subsystem, (ii) the spatial aggregation subsystem, (ii) the migration indicators subsystem, and (iii) the spatial interaction modelling subsystem (Figure 1). Each subsystem is autonomous, supporting standardised input and output data in addition to the required tasks. The studio is currently designed to process and analyse data relating to one country at a time. The initial subsystem is responsible for data preparation. It is essential that the raw data for the country selected, such as the BSU boundaries, the inter-BSU migration matrices and the BSU populations are transformed into normalized data sets for feeding the other two subsystems. The geographic data are usually either in the WGS84 projection system (geodetic projection) or in a national projection system (planar projection) of the country concerned whilst the tabular migration data are comma delimited origin-destination matrices or pairs of migration flows. The standardisation of these data sets is achieved by the system that provides the environment to load, convert and export the data.

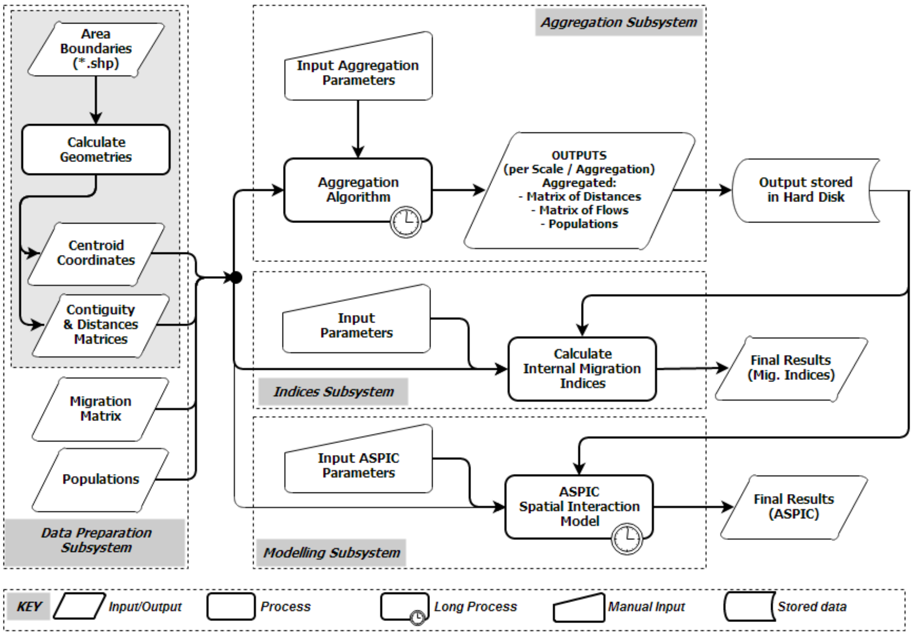


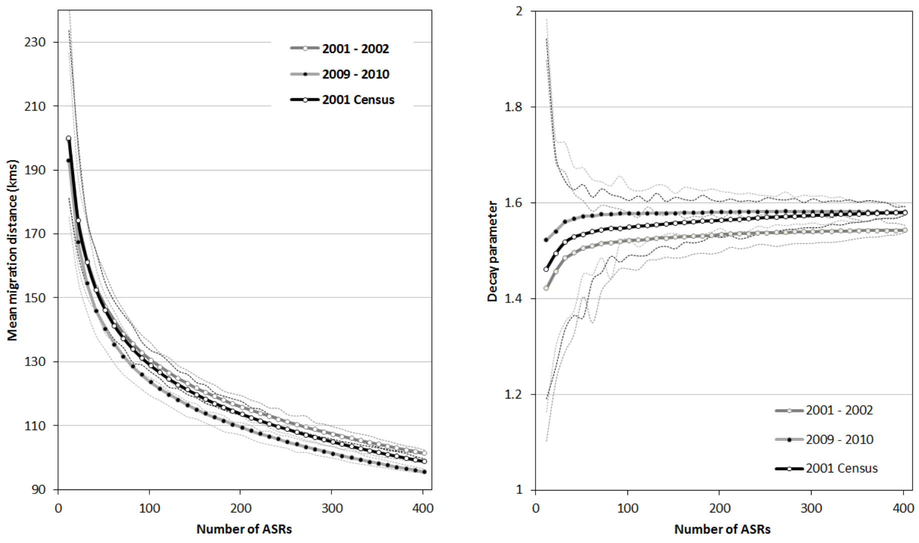
Figure 1: Subsystems of the IMAGE studio

The second subsystem shown in Figure 1 constructs the spatial aggregations at different scales and with various compositions of BSUs in a stepwise manner. It involves the implementation of an aggregation algorithm (Openshaw, 1977; Daras, 2006) that is fed with normalised data from the data preparation subsystem and produces aggregated information such as contiguities, flow matrices and populations for each newly created set of Aggregated Spatial Regions (ASRs). The third subsystem computes global (systemwide) internal migration indicators, as suggested by Bell *et al.* (2002), for every spatial aggregation and also calculates the descriptive statistics for each set of migration indicators with different ASR configurations. The indicators include those. Finally, the fourth subsystem enables the calibration of a doubly constrained spatial interaction model (SIM) (Wilson, 1970; Stillwell, 1990) either for the migration flows for the initial set of BSUs or for the migration flows for each set of ASRs. The subsystem makes use of a modelling code called ASPIC (ARC SPatial Interaction Collection) which has been written in FORTRAN which it provides with a configuration file with all the relevant information about the source of the data files in the hard disk and allows the user to set the required parameters for executing the SIM model. The system uses output data from the spatial aggregation process and, for each aggregation, produces a document with the results of each SIM analysis as well as averaged model statistics and goodness of fit measures.

In general, all the spatial operations (such as adjacency and retrieval of polygon centroids) are delivered by making use of the SharpMap and Net Topology Suite (NTS) libraries. The NTS provides a group of methods that deliver topological functionality in geographical data while the SharpMap library handles the user interface. Both libraries are developed according to the simple feature specifications by Open Geospatial Consortium (OGC) and they are open source accessed.

3. Modelling internal migration in the United Kingdom

Two data sets for a system of 406 local authority districts in the UK have been used for aggregation in steps of 10 with 1,000 aggregations generated from random seeds at each step using the IRA-wave aggregation (Openshaw, 1977). The first data set is from the 2001 Census and includes flows of migrants in the 12 months before the census date. The second data sets contains data estimated from administrative sources for mid-2009-10 (Lomax *et al.*, 2013). No intra-region flows have been included in either matrix so there is a steady decline in the number of migrants with the fall in the number of regions as aggregation occurs. The total number of migrants between the BSUs is around 2.5 million in the 2000-01 data and over 2.8 million in the 2009-10 matrix. The mean of the mean distances of migration and the mean values of the model decay parameters at each step are shown in Figure 2. The horizontal axes of both graphs have units that range from 2 to 402 regions in steps of 10. The distance decay values are very similar (1.5807) for the original system of 406 BSUs in both time periods and mean migration distance is 98.5kms in 2001-02 and 95.4kms in 2009-10. Thereafter, as the number of regions in the system decreases, there is a very gradual decline in the frictional effect of distance in 2001 until around 40 regions, after which the parameter value declines more rapidly and the frictional effect of distance on migration reduces whilst, at the same time, the mean distance of migration increases considerably. The range of decay parameter values associated with the iterations at each step is also shown on the graph (dotted lines), indicating that as the number of regions in the system gets smaller, the variation in the parameter value increases around the mean, suggesting much greater instability in the decay parameter when modelling smaller sets of regions.



(a) Mean migration distances (b) Distance decay parameters

Figure 2: Average mean migration distances and decay parameters, 2000-01, 2001-02 and 2009-10

A comparison of the average decay parameters and migration distances in the UK between the two estimated data sets suggests that the frictional effect of distance on migration is slightly more important in the 2009-10 data with the mean distances of migration at all levels of aggregation being slightly shorter. In general, the decay parameters for both periods show surprising consistency across the range of aggregations.

4. Conclusions

The results presented for the UK illustrate the extent of the MAUP scale and zonation effects when analysing internal migration in the UK. They suggest that the scale effect of the friction of distance on migration is relatively small when the spatial system contains over 40 regions but varies more with lower numbers of regions. Similarly, the aggregation effect is also more apparent when the spatial system contains relatively low numbers of regions, as indicated by the widening of the range around the mean values of the decay parameter. On the other hand, there is a significant scale effect evident in the mean distance of migration which shows an exponential increase as the number of regions declines, but the aggregation effect is minimal throughout the series of steps.

The paper will be extended to investigate the variations that occur in other migration indicators at different spatial scales and with different ASR configurations. In addition, scale and zonation effects will be examined using migration flows disaggregated by selected demographic and socio-economic variables including age, gender, ethnicity, health and economic activity, flows that are available either from published 2001 Census tables or from estimates derived from administrative data during the intercensal period.

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