Analysing sociodemographic spatial change in the UK: data and computational issues and solutions

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Abstract

In the UK there has been a large expansion in the availability of spatially referenced Census, Vital Statistics and administrative data over the last few decades. This has been paralleled by increases in computer power, the sophistication of analysis packages and of programmer and user skills. To investigate trends and identify change over time we need data consistent in definition over time and space. Unfortunately, a variety of technical issues need to be overcome before even a rudimentary analysis can be carried out.

Attribute data may vary over time in terms of topic availability, definition and the demographic detail for which variables are released. Similarly, the geography for which data are available may change through time either due to a decision about the geographic scale of release or because a boundary change has occurred. These difficulties are compounded by the variety of geographies for which data may be disseminated. For time-series analysis, harmonisation of both attribute and geographical information is essential. In this paper some examples of problems and solutions are given.

Keywords: Boundary change; Data harmonisation; Census; GIS; UK

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1. Introduction

In the UK there has been a large expansion in the availability of spatially referenced sociodemographic data over the last few decades. This has been paralleled by increases in computer power, the sophistication of analysis packages and of programmer and user skills. The UK's decennial Census provides detailed sociodemographic information from national to local level. Censuses enable descriptions of population size and characteristics and the calculation of, for example, rates of illness or unemployment by population sub-group and local geographies. We also have high quality information on births and deaths from the Vital Statistics (VS). The VS have been available annually since the 1980s in computerised formats and underpin the calculation of fertility and mortality trends (Rees *et al.* 2003). We have little information, however, about movements over the life-course due to a paucity of subnational and international migration data since we do not have national registration, unlike Scandinavian countries and the Netherlands.

The application of demographic methods help us study population structure and the components of change. Demographic techniques can reveal inequalities between population sub-groups (by sex, ethnic group or social class, for example) and between locations. To investigate trends and identify change over time we need data consistent in definition over time and space. Unfortunately, there are a variety of issues to be overcome before even a rudimentary analysis can be carried out. Relating to attributes these problems include: changes in the questions asked and the definitions and classifications used and changes in tabulations. In relation to geography, problems include: changes in the scale and type of areas for which data are disseminated and changes in the boundaries of areas for which data are available (Norris and Mounsey 1983).

This paper will first illustrate issues regarding inconsistencies in attribute information over time with some harmonisation solutions identified which researchers might consider using. In the following section, the harmonisation of geographical boundary systems over time is discussed. The overall aim of the paper being to act as a resource for researchers entering this area of research. The issues and techniques being discussed here are being investigated and applied during ongoing demographic research (Norman 2006).

2. Harmonisation of attribute information

Demographic data have been available from the Registrar General's decennial reports since 1851 (the legal requirement to register births and deaths began in 1938). Vital Statistics on births and deaths

have been available annually in computerised formats since 1981 at various geographic scales. Inevitably, an analysis of a sociodemographic time-series will rely on the UK's decennial censuses which have been collected since 1801 and in computerised formats from 1971. Thus the main focus here is on sources that will help the researcher disentangle inconsistencies in attribute information available in the censuses. Conceptually the challenges of a time-series of births and deaths data are more straightforward but compatibility cannot be assumed.

In terms of continuity between censuses "there is an inherent tension in the decisions over introducing new topics and dropping old ones, reflecting changing needs for information whilst retaining comparability with previous censuses" (Marsh 1993: 7). Thus, the first check to make is whether the topic and questions of interest have been asked in successive censuses. Fortunately, much painstaking work has already been carried out and the researcher should spend time absorbing the wealth of information contained in Norris and Mounsey (1983), Dale (1993) and Champion (1995).

Where the topic exists across time but the detail varies, a researcher might be faced with the following choices: to aggregate differently detailed information to broader groupings that are in common; or to estimate a disaggregation of grouped information to the detail required. The disadvantage of the former is that detail which may have been of interest may be lost, the disadvantage of the latter is that the estimation may be unreliable. Where a topic was not included or information disseminated differently, an estimation using a surrogate variable may be possible. Some examples are outlined below.

It would be reasonable to assume that population counts are consistent from one time point to the next. This will not necessarily be the case since the census population definitional 'base' may vary. Dale (1993) identifies two basic methods of enumeration: first, to count everyone *present* in the household on census night, irrespective of where they usually live; and second, to count everyone who is *usually resident* in the household, irrespective of whether they are present or absent on census night. Before using population counts as denominators in rates or to calculate change in population size, check that the bases are consistent. Check also whether tables are populations in households or communal establishments and whether students are enumerated at their term-time or parental addresses.

In terms of population characteristics, check that categories are consistent. For instance, a question about each person's ethnicity was included in the 1991 Census with the topic repeated in 2001. In 1991 the ethnic group information was released as 10 main output categories but in 2001 the ethnic group categories were changed resulting in a total of 16 categories. To align the 1991 and 2001 ethnic groups, a solution is to amalgamate categories to those thought to be compatible (Simpson 2002b).

The 8 categories which result (table 1) can be used to investigate changes in ethnic group proportions during the inter-censal period.

[Table 1 about here]

For a longitudinal study 1971-1991, Norman *et al.* (2005) needed to calculate Carstairs deprivation scores for 1971 but an input variable to this index, Low Social Class, was unavailable for that year. ONS (2004) provide tables linking various socioeconomic classifications. This enabled 1971 Census data on various socioeconomic groups to be approximated as Social Class IV and V using an interim variable NS-SEC Operational Categories (see Table 2).

[Table 2 about here]

The demographic detail in both census and VS data can vary between time points. Census data, for example, tends to be banded into age-groups for confidentiality reasons but this also reduces file sizes that accrue with single year of age information which can prove overwhelming to inexperienced researchers. VS data are also released with age information grouped. Several difficulties with census and VS age information can arise. Age bandings can vary between time points and the detail for which age is released may not be the detail required for a study. Since more demographic detail is released at national and regional levels in census tables than for data released for district and sub-district geographic scales, age bandings can vary between tables from the *same* census.

A common age banding is for 'quinary' 5 year groups. Whilst much sociodemographic data area released for these groupings some variations occur. The oldest age-group has for many years been for those persons aged 85 and over (often labelled 85+). Reflecting increasing life expectancy and ageing populations, more recently quinary data have been released up to ages 85-89 and 90+. The youngest ages often have ages 0 and 1-4 rather than just 0-4 and occasionally there are splits in the late teenage years to allow rates to be appropriate to school age and young adult applications.

To harmonise age bandings, groups can be aggregated to the detail in common between sources. The VS2 has information about the age of mother when she gives birth to a child. Table 3 shows that prior to 2000, the age breakdown in late teenage years is different to that released for 2000 onwards. A solution in this instance is to aggregate to a 16-19 age-group. Alternatively, to match datasets or to have a different grouping from the available information, a disaggregation may be required. Hierarchically applying more detailed information available for a large geographical area to a sub-geography is a strategy worth adopting. For example, if mortality by single year of age were needed for a study at ward level, the grouped information in the VS4 can be disaggregated using national schedules for within group proportions.

[Table 3 about here]

The examples given here have flagged difficulties which may be encountered and suggested approaches for harmonising a time-series of attribute data. In the next section of the paper, harmonisation of the geography for which data are released will be considered.

3. Harmonisation of geography

The UK is subject to more administrative boundary changes over time than the rest of Europe put together (ONS, 2000). For example, within local authorities, electoral ward boundaries are regularly adjusted in response to population change to ensure each local authority has similar elector to councillor ratios (Norman *et al.,* 2007). Figure 1 shows that between the 1991 and 2001 Censuses there have been many changes to the constituent wards in the local government district of Welwyn-Hatfield which prevent direct comparisons over time. Even if boundaries do not change, area names and reference codes often vary with different versions and spellings used across years and between different data suppliers and agencies. These issues are compounded by the large number of different geographies for which data are available and by technical difficulties because the UK's administrative and postal geographies do not align. Unless a consistent geographical approach is taken with time-series data it cannot be known whether changes in the relationships between variables collected for areas are real or an artefact of the boundary system in which they were collected (Norman *et al.,* 2003).

[Figure 1 about here]

A conceptual framework within which to address this problem is a Geographical Conversion Table (GCT) (Simpson 2002a). Essential to a GCT is an estimate of the size of the overlap intersection between source geography (the set of areas in which data pre-exist) and the target geography (the set of zones for which data are needed) so that the data can be apportioned between the boundary systems. 'Size' in this application will not be the areal extent but will relate to population distribution since this is not even across space. Thus proxy indicators of distribution are used (Simpson 2002a). Until recently, the tendency has been for *ad hoc* solutions to particular problems (see Norman *et al.* 2003; Simpson 2002a); a generically applicable approach is outlined below.

Postcode directories with links to administrative geographies within which each postcode lies can be used within the GCT framework. The principle of this approach is to disaggregate sociodemographic data for the source geography to a set of postcodes that comprise each source-target intersection and then to reaggregate the data to the target geography using the postcodes which comprise each target unit. In GIS parlance, postcodes are invariably taken to be 'point' entities, located in space in the UK using the grid reference of their centroid. Figure 2 illustrates a changing hypothetical ward geography; the research need is for data to be in the target year geography. In the source year, North and South wards have a constituent set of postcodes, their point locations marked (white and black **X**'s respectively). In the target year, East and West wards have been created occupying the same areal

extent as the previous wards and each containing postcodes previously associated with North and South wards.

[Figure 2 about here]

Population data for North ward can be apportioned using the proportion of postcodes falling in the intersection between North and West wards (6/9) and between North and East wards (3/9). Similarly, South ward's population can be apportioned using the proportion of postcodes in the South and West ward (4/6) and South and East ward (2/6). If the populations of North and South wards were 9,000 and 6,000 these can be apportioned to the alternative wards as follows:

West ward = 10,000 comprising part of North (9,000 x 6/9) plus part of South (6,000 x 4/6)

East ward = 5,000 comprising part of North (9,000 x 3/9) plus part of South (6,000 x 2/6)

The assumption of this approach is that the distribution of residential postcodes is a proxy for population distribution. Since people are not evenly distributed across postcodes (with an urban-rural gradient, for example) the disaggregation weights are enhanced by the use of address, person or household counts at each postcode.

It should be noted that, if sociodemographic data are to be converted from one geography to another, it is the raw counts which must be converted not rates, percentages or other derived data (e.g. deprivation scores or geodemographic profiles). If the unemployment rate for ward 'A' was 20% and contiguous ward 'B' was 15%, as in table 4, and their shared boundary moved such that a proportion of ward A was transferred to B. 5% unemployment (table 4a) cannot be subtracted from A and added to B. The procedure to adopt is to convert the raw data, then recalculate the rates. Thus, in table 4b, 25% of the numerator and denominator are transferred from ward A to ward B, which does not, in percentage terms result in any change in the unemployment rate in A. The assumption, of course, in this approach is that employed and unemployed persons are similarly distributed at sub-ward level.

[Table 4 about here]

4. Summary

In the UK there has been a large expansion in the availability of spatially referenced sociodemographic data over the last few decades which has been paralleled by increases in computer power, the sophistication of analysis packages and of programmer and user skills. It has been noted in this paper that attribute data may vary over time in terms of topic availability, definitions and the demographic detail in which variables are released. Similarly, the geography for which data are available may change through time either due to a decision about the geographic scale of release or because a boundary change has occurred. Harmonisation of both attribute and geographical information is essential so that a time-series analysis can be carried out.

Topical in the UK media are an ageing society, increased life expectancy, low fertility and teenage pregnancy. Immigration is a hot potato during current political debates with large numbers of eastern Europeans, particularly from Poland, moving into the UK following their recent accession into the European Union. There is, however, little acknowledgement of the demographic processes and geographical distributions underlying these phenomena and a danger of reporting without evidence from reliable statistics and independent research. Population geography and demography have the methods, but not always readily usable data, harmonised over time by attribute information and by geographical area, through which to highlight population change, trends and inequalities.

Acknowledgements

- 1991 and 2001 Census statistics have been collected and disseminated by the Office for National Statistics (ONS) and are Crown Copyright. They are available from ONS and through the Manchester Information and Associated Services (MIMAS), University of Manchester.
- 1991 digital maps are provided by the United Kingdom Boundary Outline and Reference Database for Education and Research Study (UKBORDERS) via Edinburgh University Data Library (EDINA) with the support of Economic and Social Research Council (ESRC) and the Joint Information Systems Committee of Higher Education Funding Councils (JISC). 1991 boundary material is Copyright of the Crown, the Post Office and the ED-LINE consortium. Digital boundaries for 2001 are provided by ONS and are Crown Copyright.
- Vital Statistics have been made available annually by the Office for Population Censuses and Surveys (OPCS) and ONS. Prior to 2000, data were obtained from the UK Data Archive, 2000 onwards from ONS. Academic user support for the VS is by ESDS Government http://www.esds.ac.uk/government/ Vital Statistics are Crown Copyright.
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Table 1: Eight ethnic group categories compatible in both 1991 and 2001

1991 Census categories	2001 Census categories	Compatible categories
White	White – British White – Irish White Other – White	White
Black – Caribbean	Black or Black British – Black Caribbean	Black Caribbean
Black – African	Black or Black British – Black African	Black African
Indian	Asian or Asian British – Indian	Indian
Pakistani	Asian or Asian British – Pakistani	Pakistani
Bangladeshi	Asian or Asian British – Bangladeshi	Bangladeshi
Chinese	Chinese or Other Ethnic Group – Chinese	Chinese
Black – Other Other – Asian Other – Other	Mixed – White and Black Caribbean Mixed – White and Black African Mixed – White and Asian Mixed – Other Mixed Black or Black British – Other Black Asian or Asian British – Other Asian Chinese or Other Ethnic Group – Other Ethnic Group	Other

Source: after Simpson (2002b: 77)

Table 2: Creating a 'Low Social Class' variable for 1971

The available data		Linking variable		The research need	
Socioeconomic Group (Table 28, 1971 Census)	**Description**	**NS-SEC Operational Categories**	**NS-SEC Operational Categories**	**Social Class**	**Description**
7	Personal service workers	12.7, 13.1	11.2, 12.2, 12.4, 12.5, 12.7, 13.1, 13.2, 13.5	**IV**	Partly skilled occupations
10	Semi-skilled manual workers	11.2, 12.2, 12.4, 13.2			
15	Agricultural workers	12.5, 13.5			
11	Unskilled manual workers	13.4	13.4	**V**	Unskilled occupations

Source: after Norman et al. (2005) based on ONS (2004)

Table 3: Harmonising age detail: aggregation of age of mother at the birth of a child

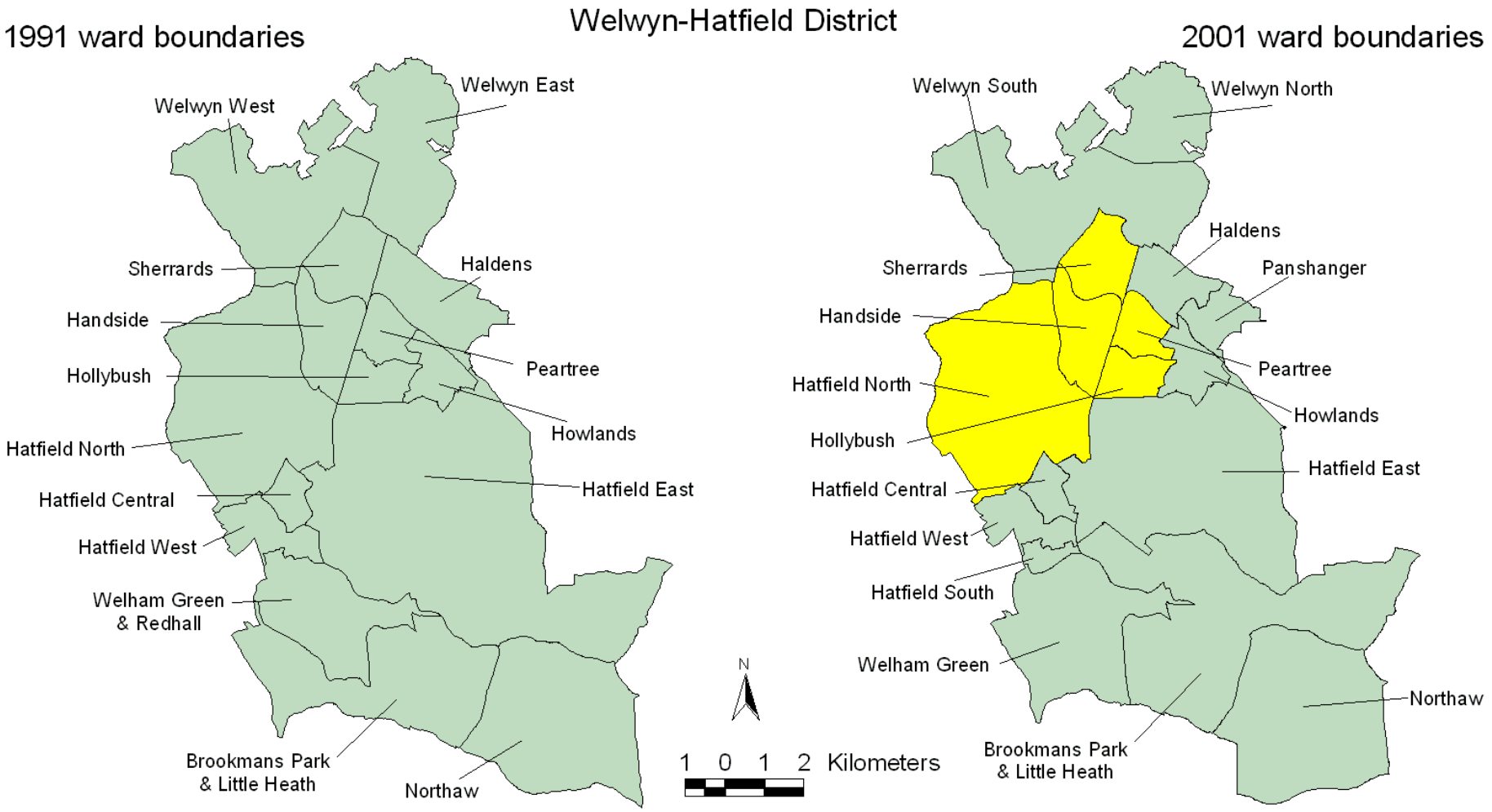
	Data Prior to 2000	Data 2000 onwards	Common detail
Age of mother at the birth of a child	11-15	11-15	11-15
	16	16-17	16-19
	17-19	18-19	
	20-24	20-24	20-24
	25-29	25-29	25-29
	30-34	30-34	30-34
	35-39	35-39	35-39
	40-44	40-44	40-44
	45+	45+	45+

Sources: UK Data Archive and ONS

Table 4: Converting rates between geographies

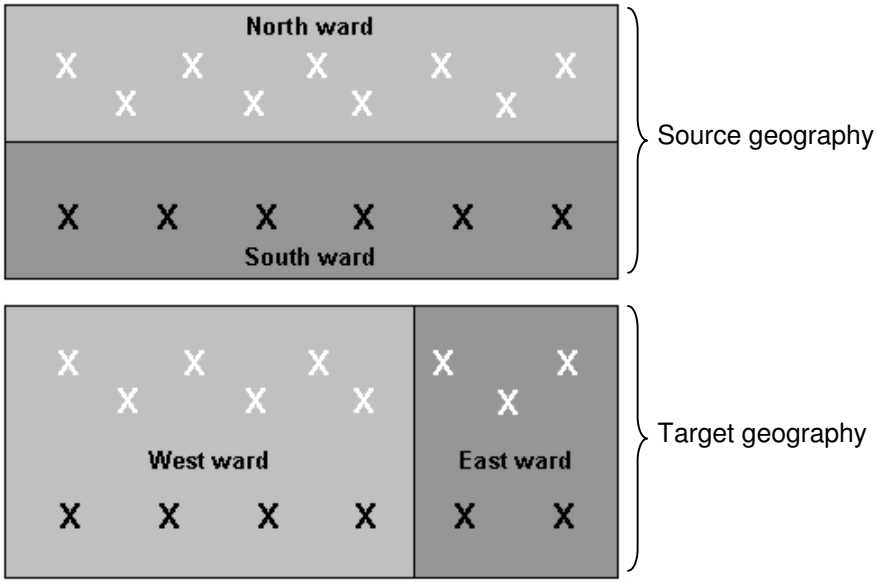
	Source geography		Conversion weight	Target geography	
a. Wrong approach	**Ward A**	**Ward B**	**0.25 (A to B)**	**Ward A**	**Ward B**
Unemployment rate	20%	15%	5% (A to B)	15%	20%
b. Right approach	**Ward A**	**Ward B**	**0.25 (A to B)**	**Ward A**	**Ward B**
Unemployed	40	15	10 (A to B)	30	25
Economically active	200	100	50 (A to B)	150	150
Unemployment rate	20%	15%		20%	16.67%

Figure 1: Electoral ward boundary changes 1991 to 2001



Source: after Norman et al. (2003)

Figure 2: Postcodes used to link geographies and weight data conversion



Source: after Norman et al. (2003)