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HARMONISING DATABASES FOR THE CROSS NATIONAL STUDY OF INTERNAL MIGRATION: LESSONS FROM AUSTRALIA AND BRITAIN

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ABSTRACT

This paper describes the way in which harmonised databases of inter-regional migration in Australia and Britain were created, classified by five year ages and birth cohorts for four five year periods between 1976 and 1996. The data processing involved estimation of migration data for temporally comparable spatial units, the aggregation of those units to a meaningful set of city regions, the extraction of migration data from official data files supplied by the Australian Bureau of Statistics and the Office for National Statistics, the filling of gaps in these files through use of various techniques including iterative proportional fitting, and the harmonisation of age time-plans through estimation of the numbers of transitions (Australia) or movements (Britain) for common age-period-cohort spaces. The final stage in preparation of the databases was to specify the populations at risk for computation of migration intensities. The creation of such databases requires integration of demographic concepts, social science estimation methods and careful bespoke computer programs: once the goal of harmonisation has been achieved standard database and statistical software can be used in the parallel analysis of migration in Australia and Britain.

Keywords. Internal migration; Australia; Britain; comparative studies

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1. INTRODUCTION

1.1 Why Construct Parallel Time Series of Migration Statistics?

Relatively little attention has been given to the ways in which within-country migration changes over time. In countries that do not have a comprehensive population register and its accompanying compulsory change-of-address recording system, the reason for this neglect is the difficulty of assembling consistent and accurate time series from partial data. To understand migration behaviour, it is essential to construct time series which are fully classified by age at migration, period of migration and cohort of birth. Such a database makes it possible to track changes over time in age-specific migration intensities and hence to analyse the influence of life course events, secular trends and birth cohort size on these intensities.

This paper sets out the procedures for constructing parallel migration databases, with the same spatial and demographic structure, for Australia and Britain as part of a project comparing inter-regional migration in the two countries. Cross-national comparisons of internal migration present a number of challenges (Bell *et al.,* forthcoming, Rees *et al.,* 2000) and these are especially apparent in the case of Australia and Britain. The migration data collected in the two countries differ in a number of crucial respects, including the way in which migration is measured (events versus transitions), the intervals over which they are collected, the populations they cover and the treatment accorded to missing data. There are marked differences, too, in the physical geography and settlement patterns of Britain and Australia.

If reliable comparisons are to be made, it is essential that the effect of such variations be minimised and, where possible, eliminated. Ideally this requires the creation of parallel databases that are harmonised in respect of four key dimensions: the time periods over which migration is recorded; the system of spatial zones between which the moves are registered;

the conceptual basis on which the migration is measured; and the age-time plan from which the movement is observed.

While the creation of databases that are fully harmonised on all of these dimensions is out of reach, it has been possible to assemble time series datasets for the two countries which are closely comparable. In practice, this meant assembling data for about 35 regions in each country, over four 5-year time periods (1976-81, 1981-86, 1986-91, 1991-96), using two sexes, fifteen five-year age groups (0-4, 5-9, ... , 65-69, 70+), and nineteen five-year birth cohorts (pre-1906, 1906-11, ... , 1986-91, 1991-96). Several of the issues involved in this harmonisation of databases are described in discrete contributions elsewhere (see Bell *et al*., 1999; Blake *et al*., 2000; Rees *et al*., 2000; Bell and Rees, 2000). The purpose of this paper is to bring together the various elements and procedures in a single overview of the harmonisation process.

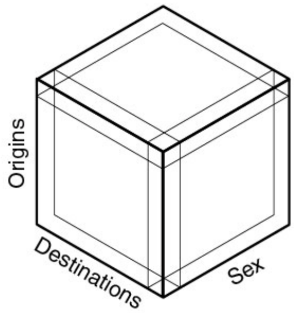
1.2 The Nature of the Parallel Databases

The organising framework for the databases in each country is a Sex-Origin-Destination-Age-Period-Cohort (SODAPC) array of migration flows. Figure 1 provides a picture of what a SODAPC array looks like in conceptual form. It is not, of course, possible to represent a six dimensional array on a two dimensional plane, so the array is shown as two sets of three-dimensional diagrams, which are combined to form the full database.

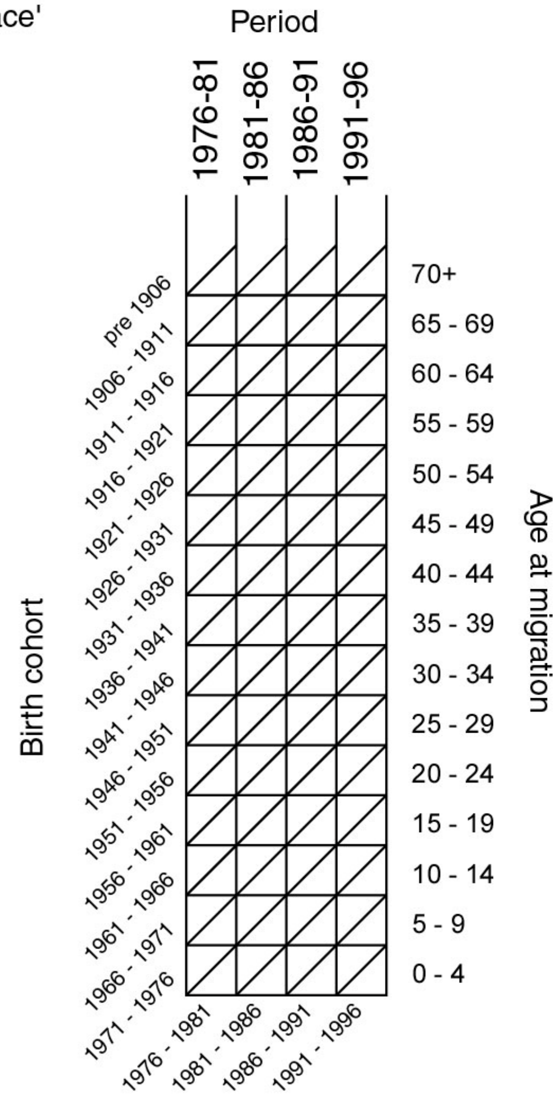
The top diagram in Figure 1 shows the SOD face of the full array: Sex by Origin by Destination. The interior of the cube is occupied by triply classified cells, which contain counts of migrants or migrations. The sex component plays a very simple role in the database: every migration flow is given for males and females, and therefore implicitly for persons. The origin-destination face of the SOD array is symmetrical: origin and destination regions are defined to be similar kinds of region, city regions (spheres of influence) in both countries,

Figure 1. Dimensions of the harmonised database: sex-origin-destination by age-period-cohort

a. The SOD 'Face'



b. The APC 'Face'



because this is the only geographical classification that makes sense in the real space-economy. These regions need to be defined consistently over time, because otherwise the change measured over time is artefactual rather than real.

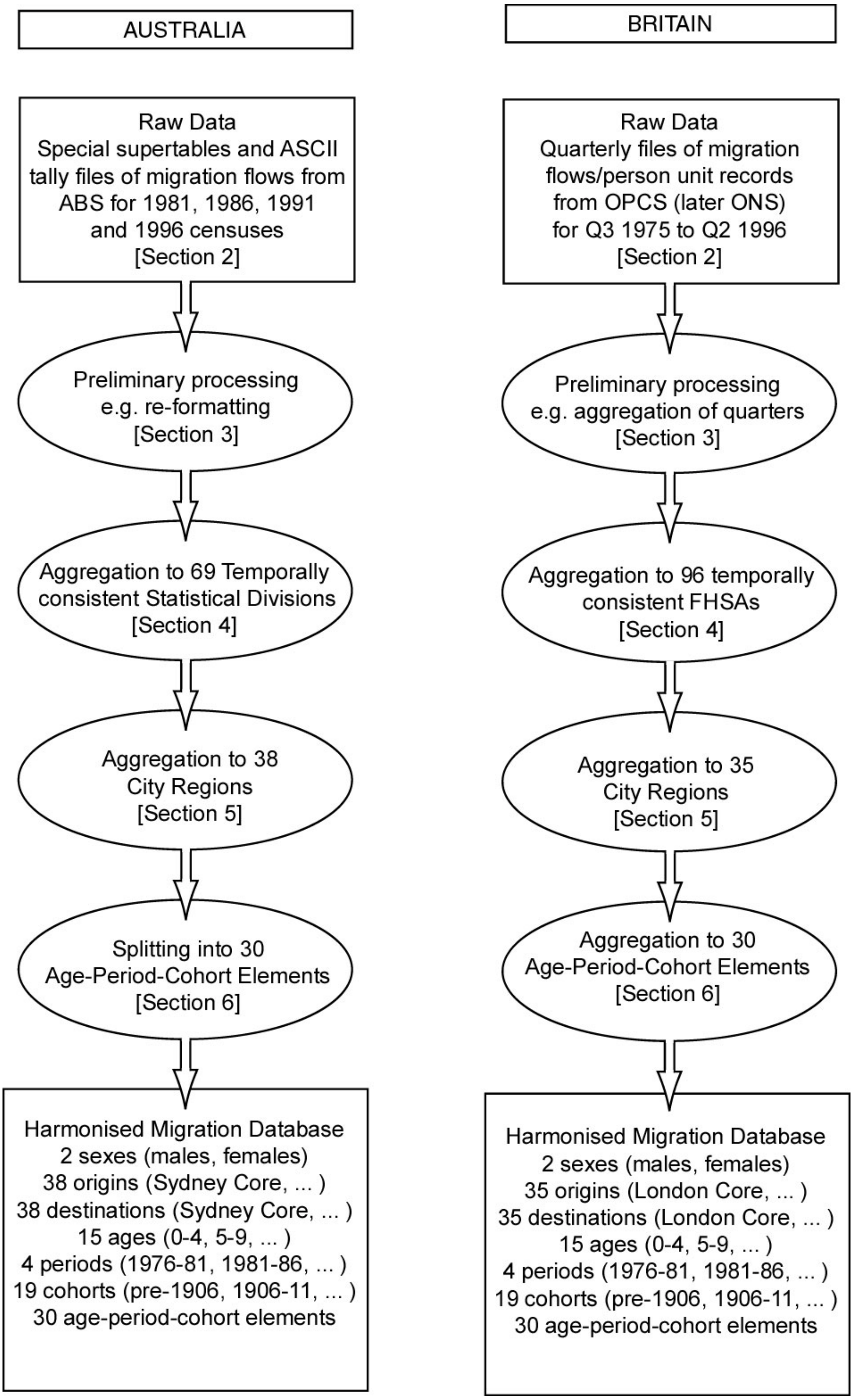
The bottom diagram in Figure 1 shows the APC face of the full array. Each triangular APC space in this diagram is occupied by a count of migrants or migrations. Migration flows are classified in this array by age at time of migration, by period of migration and by birth cohort membership. An explicit third dimension for birth cohort is not needed if there is exact information on time of migration and birth date of migrant, because the birth cohort can then be deduced directly. However, these data are lacking in both Britain and Australia so in order to make the data fully comparable we need to so develop methods to estimate the triple classification of register-based migration in Britain and census-based migration in Australia.

Each element in the SOD array can be cross-classified against any element in the APC array and any subset of information retrieved from the full database. For example, we can look at the way in which migrations in a particular age group from an origin vary by period. Or we can examine how the origin to destination flows of a particular birth cohort vary over the four periods for which we have information. Once the full array has been "populated" with reliable estimates, the information can also be used to compare migration behaviour in the two countries at the national scale (Bell *et al.*, forthcoming).

1.3 The Tasks in Database Creation

The main tasks to be accomplished are set out in Figure 2 as a series of steps in two parallel sets of processes, which transform the raw data into harmonised databases. The first task was to acquire from the Australian Bureau of Statistics (ABS) and the Office for National Statistics (ONS) data files relating to migration over a common 20-year period from 1976 to 1996. The raw Australian data are stored by ABS as origin-destination flows between

Figure 2. A flow diagram of the procedures used to assemble the harmonised Australian and UK databases



Statistical Local Areas (SLAs - the main sub-State reporting areas used in the Australian Census). The data are contained in four separate files from the censuses of 1981, 1986, 1991 and 1996, each covering a five year interval. The raw British data consist of quarterly files of inter-FHSA migration from the third quarter (Q3) of 1975 to the second quarter (Q2) of 1996. In the period Q3-1975 to Q2-1983, the migration data are provided as three tables: origins by destinations (OD), origins by age and sex (OAS) and destinations by age and sex (DAS). From Q3-1983 to Q2-1996, the data are available as individual migration records from which full flow arrays can be constructed (ODAS). The characteristics of the Australian and British migration data are set out in more detail detailed in section 2.

The second task was to carry out preliminary processing of the Australian and British migration statistics into suitable formats. For example, the British quarterly data were aggregated into annual, mid-year to mid-year periods. There was also the need to estimate the full ODAS array for 1975-83 for Britain so that the same migration flows were available for all five-year periods. Details of preliminary processing are given in section 3.

The third task was to aggregate the data from the spatial units provided in the raw files to a temporally-consistent set of spatial units. This is essential if time series analysis of the harmonised data is planned, but national statistical offices rarely provide data series retrospectively adjusted to achieve spatial consistency. The methods adopted are described in section 4.

Because the spatial units available in Australia and Britain differed so much in original purpose - statistical reporting area (Australia) versus administrative unit in the public health service (Britain) - it is important for cross-national comparison to identify some common zonal system. We achieved this by aggregation to city regions, which are the organisers and driving forces of the space-economies of both countries. The logic of these spatial structures is explained in section 5.

The final task is to process the data into age-period-cohort migration flows. This is necessary because the Australian data are reported in period-cohort form, whereas the British data are reported in period-age form. So that comparisons can be made each Australian period-cohort migration flow and each British migration period-age flow is disaggregated into age-period-cohort elements. An overview of the procedures is provided in section 6, with a full account set out in Bell and Rees (2000).

The final section of the paper briefly summarises the content of the two harmonised databases and indicates the comparative analyses that are made possible. It also draws lessons for the extension of harmonisation to migration data sets in other countries.

2. THE AUSTRALIAN AND BRITISH MIGRATION STATISTICS

2.1 Sources of Australian and British Migration Data

In Australia the only comprehensive source of data on internal migration is the Population Census. Australian Census data on internal migration derive from a series of multi-part questions that seek each person's place of usual residence on Census night and their usual address five years previously. Similar data have been collected at each quinquennial Census since 1971. Since 1976 a question on place of usual residence one year ago has also been included. Except for the 1991 Census, when the one year question was restricted to the state level, usual address has been coded to SLA level (Census Local Government Area level prior to 1986).

The strengths of the Australian migration data derive from consistently low levels of underenumeration (under 2 per cent), the extensive range of individual and housing characteristics collected (which can be cross-tabulated with migration status), and the fine spatial mesh which is available (since current and previous residence is coded to more than 1300 SLAs). It's main limitations reflect the conventional problems of transition data:

relatively high rates of non-response to questions on place of previous residence (around 5 per cent); the fact that only a single change of residence is captured, thereby missing any intervening moves; and the frequent changes that have occurred in the boundaries of SLAs, which seriously prejudice temporal comparability. The quality of data from the 1996 Census was also affected by deficiencies in coding (Bell and Stratton, 1998). Despite these shortcomings, migration data from the Census have been subjected to rigorous analysis following each successive enumeration since 1971 (McKay and Whitelaw, 1978; Rowland, 1979; Maher, 1984; Bell, 1992, 1995; Bell and Hugo, 2000).

The APC database covers the period 1976 to 1996 and draws on five year interval migration data from the 1981, 1986, 1991 and 1996 enumerations. The data were acquired as special multidimensional ODAS tabulations from the ABS in two file formats: as *Supertable* output files which are convenient for generating aggregated tables but cannot be readily used as inputs to further processes, and as ASCII database records giving sex, origin code, destination code, age code and the migrant count, which can be input to other computer programs or statistical packages.

In the United Kingdom decennial censuses since 1961 have asked migration questions, but they cover only one year in the decade (except in 1971 when a five-year question was also asked). Since 1975 the Office for National Statistics (formerly the Office for Population Censuses and Surveys) has published migration statistics for each quarter based on information generated from the maintenance of the National Health Service Central Register (NHSCR). This information consists of records of NHS patient re-registrations that cross the boundaries of the administrative areas of the family doctor service. From 1975 to 1983 these areas were referred to as Family Practitioner Committee areas (FPCs) and between 1983 and 1996 as Family Health Service Authorities (FHSAs). FHSAs have recently been merged into Health Area authorities, which procure patient services within the NHS and from 1999 migration statistics will be published for these new spatial units. A full account of the NHSCR migration statistics is provided by Duke-Williams and Stillwell (1999).

The NHSCR migration statistics are not quite comprehensive. They do not measure migration within FHSA area; they undercount migrations by young adult males who may migrate several times before registering; and they omit groups whose medical care is wholly provided by non-NHS bodies (the Armed Forces, the Prison Service, private health schemes). However, they are the best time series data available and have been extensively used in previous research (Stillwell *et al*., 1992, 1996).

The British migration data have been acquired from the Migration Statistics division of the Office for National Statistics over a number of years as a standard set of files and used in other projects (see Stillwell *et al*., 1992; Duke-Williams and Stillwell, 1999). The data files provided by ONS are available for licensing quarter by quarter from 1975-Q3 to the latest quarter (usually two or three quarters in lag from the current). In this work we restrict attention to the period 1976-Q3 to 1996-Q2. For the period 1976-Q3 to 1983-Q2, the files consist of records with three separate arrays: an Origin-Age-Sex (OAS) array, a Destination-Age-Sex (DAS) array and an Origin-Destination (OD) array. Between 1983-Q3 and 1996-Q2, the files contain person unit data (PUD) made up of migration records classified by sex, origin, destination, age at time of migration and date of birth. ONS are planning in the near future to make available a new source of local migration data based on address matching of NHS Register individual files one year apart (Scott and Kilbey, 1999). This new source would make possible the reporting of migration flows between Local Government Areas and Wards.

2.2 Concepts in the Australian and British Migration Data

The British NHSCR migration statistics refer to *movements* or migration events. It is thus possible for an individual to make more than one migration in a given time interval. By contrast, the Australian Census data measure migration as a *transition* between two fixed points in time and therefore capture only a single migration (see Rees, 1977). To convert movement statistics to transition data, or vice versa is not possible except in a very crude way, because any conversion method would need data on the number of moves per transition at different scales, and to our knowledge no such information exists either in Australia or Britain. So, ultimately, the migration data for the two countries remain non-comparable, although we have used census data for single years as the basis for comparison in other analyses (Bell *et al*., forthcoming; Rees *et al*., 2000). Despite this inconsistency, it is of great value for comparison to harmonise the spatial, temporal and age definitions in the data.

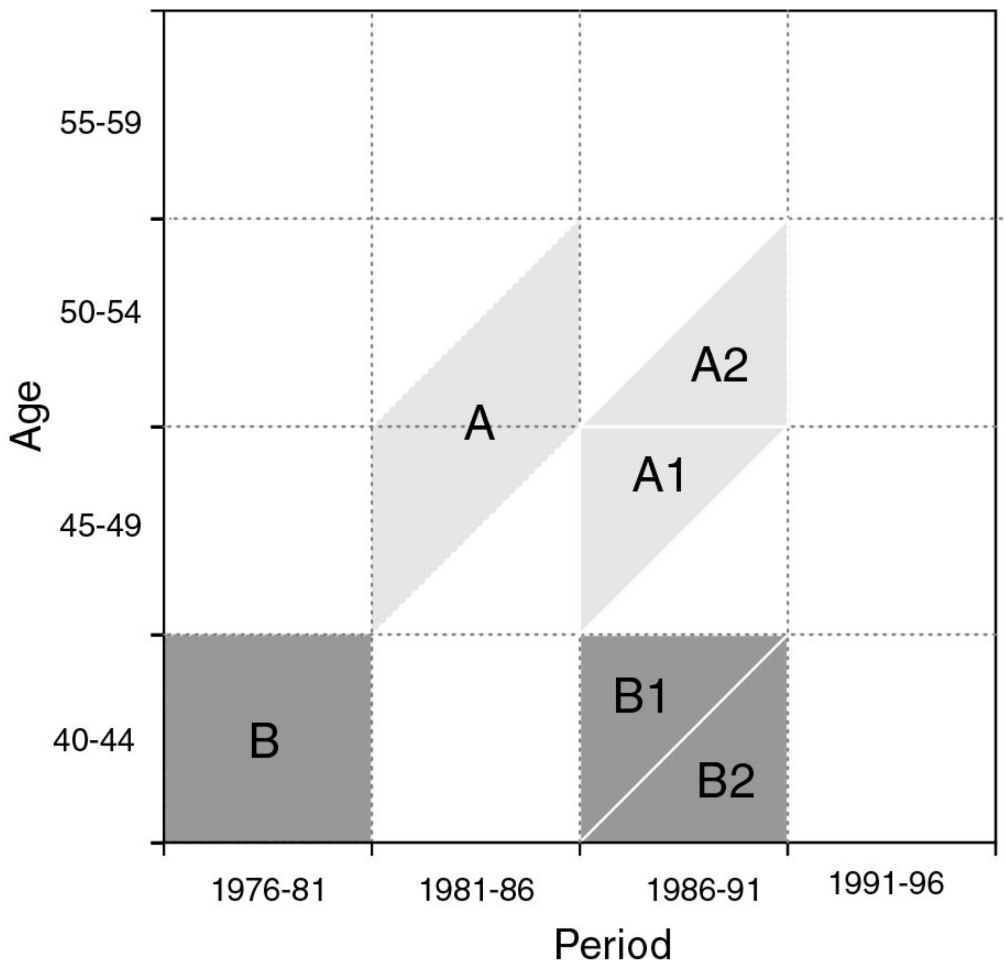
2.3 The Temporal Stability of Spatial Units

The geography of the migration data was handled in two stages: first, the data were assembled for the most detailed zonal system feasible in each country; they were then aggregated into comparable city-region systems for analysis (see section 5). In Australia, although migration data are available from each census at SLA level, these areas are subject to frequent shifts in municipal boundaries. The ABS attempts to solve this problem by publishing data for Statistical Divisions (SDs), designed as relatively large, functional regions which would remain stable for statistical purposes over a period of 20 years or more (ABS, 1996:15). In practice, however, SD boundaries underwent a number of changes over the 1976-1996 period, so a new regional structure consisting of 69 zones which are spatially consistent over the full twenty year period was created. The derivation of this set of zones, termed Temporally-consistent Statistical Divisions or TSDs, is summarised in section 4 and set out in detail in Blake *et al*. (2000). The FHSAs in Britain posed fewer problems of temporal consistency, being based on large administrative units such as shire counties or metropolitan districts, but some aggregation was necessary.

2.4 Age-Time Plans in the Australian and British Migration Data

Another important variation between the Australian and British migration data is that they are based on differing observation plans. The nature of this variation, and its implications for cross-national comparison, are most readily understood by reference to the well-known Lexis diagram which graphs age against time (Vanderschrick, 1992). This diagram makes possible the identification of several types of age-time observation plan, two of which are shown in Figure 3. Migration data generated from a retrospective question in the census are reported in period-cohort form, and conventionally labelled by reference to age at the end of the recording interval. So, for example, migrants recorded as aged 50-54 in the 1986 Australian Census were aged 45-49 five years earlier. The transition therefore occured somewhere in the period-cohort space labeled 'A' but it is not possible to determine the precise age at which migration took place: in fact, as noted above, several moves may have occurred. The British data, by contrast, record the age at which the migration event took place, reflecting a period-age observation plan. Thus the period-age space labelled 'B' captures counts of migration events occuring between 1976 and 1981 to people aged 40-44 at the time of the event. Some of these would have occurred to the cohort aged 40-44 in 1981, and some to their predecessors, the cohort aged 45-49, but the British data do allow us to segment the contributions of these two cohorts directly.

Figure 3. Age-time observation plans for migration data: period-cohort and period-age data split into APC spaces



To provide for maximum flexibility in comparing the two datasets, we estimate for each the number of migrations (events or transitions) taking place in each age-period-cohort (APC) space. In Figure 3, for example, we segment the transitions recorded among the cohort aged 50-54 in 1991, into those occurring at ages 45-49 and at ages 50-54 (areas A1 and A2 in the diagram). Similarly, period-age spaces need to be divided into component age-period-cohort spaces, as shown in areas B1 and B2 for migrations occurring at ages 40-44 between 1986 and 1991. Solutions to this estimation problem are summarised in section 6 and discussed in detail by Bell and Rees (in preparation).

3. PRELIMINARY PROCESSING AND FILLING IN THE GAPS

Ideally, we wished to follow the migration careers of birth cohorts over their lifetimes, for at least seven decades, as other researchers are able to track mortality and fertility experience. In practice, good inter-area migration data were only available from the 1976 Census in Australia (covering the 1971-76 period). Although British censuses have generated inter-regional migration data since 1961, the Census question has generally refered to the one year interval immediately prior to the census. Comprehensive coverage of inter-area migration for all years only starts in mid-1975, with the release of data from the patient re-registration records of the National Health Service Central Register, although these only record migration across the boundaries of NHS administrative areas. So the period of study was effectively defined by the data available in the two countries: that is, 1976 to 1996. More precisely, the database covers the period from mid-1976 to mid-1996 in the UK, and from June 1976 to August 1996 in Australia, since the date of the Australian census was shifted from 30th June in 1981 and 1986, to 6th August in 1991 and 1996 in the endeavour to minimise the incidence of temporary absences from home (ABS, 1991).

3.1 Processing the Australian Migration Data

Four origin-destination-age-sex arrays were acquired from ABS containing migration flows between the 69 TSDs over the five year periods 1976-81, 1981-86, 1986-91 and 1991-96. ABS was supplied with look-up tables for each census that converted Statistical Local Areas (SLAs) to TSDs (see section 4.1 for details). ABS produced special multi-dimensional tables to the project's specification. Each origin-destination flow was cross-classified by sex and 16 five year age groups (0-4 to 75 and over). A migration indicator was also included to differentiate people who moved within the same region from those who remained at the same address. These arrays came in two forms: a binary format that could only be read by specialised Supertable software, and an *ASCII* format that could be more readily accessed by other packages or by user-written programs. While Supertable provides a quick and user-friendly means of table generation, the procedures involved in harmonisation with the British data necessitated the more flexible ASCII format. This subsequent processing was undertaken using a purpose-written Visual Basic program.

3.2 Processing the British Data

The migration statistics from the NHSCR have been progressively assembled at the School of Geography, University of Leeds, into a database and extraction system called Time Series of Migration Data or TIMMIG. The original version of this system (described in Rees and Duke-Williams, 1993) has been upgraded with the addition of migration data from Quarter 3, 1992 to Quarter 2, 1998, to form a sequence that runs for 23 consecutive years from mid-year 1975 to mid-year 1998 (Duke-Williams and Stillwell, 1999). For the current project migration statistics were extracted from the TIMMIG database for mid-year to mid-year periods from July 1 1976 to June 30 1996.

The files for mid-year 1983 to mid-year 1996 are full origin-destination-age-sex (SODA) arrays. The origins and destinations are FHSAs in England and Wales and Area

Health Boards in Scotland. Aggregations were carried out on these files to achieve full time-consistency of areas over the whole mid-1976 to mid-1996 period (see section 4.2 for details) and then directly from TIMMIG to the harmonised city region geography (see section 5.2). These files were then input to the age-period-cohort processing described in section 6.2.

Full SODA arrays are not available for the mid-1976 to mid-1983 period. OPCS has only published separate origin-destination (OD), origin-age-sex (OAS) and destination (DAS) sub-arrays. To create a uniform dataset through the study period, it was decided to model the contents of the full SODA array from this partial information using iterative proportional fitting (IPF). The framework and techniques for filling such arrays were developed by Willekens in the 1970s (Willekens *et al*., 1978; Rees and Willekens, 1986). Although these techniques do not recover the original SODA flows with full accuracy, use of the OD, OAS and DAS arrays aggregated to 35 regions and the later aggregation of the results to five year time periods yield estimates very close to the observed flows.

Figure 4 shows the IPF routine used. Before the routine is initiated, a check is made that the contents of each of the sub-arrays sums to the same total. Unless this condition is met the IPF routine will not converge. In Step 1, the simple assumption is made that each cell in the array contains one migration. The alternative assumption that the migration elements were the same as those observed during the previous period proved unsatisfactory with such a potentially sparse array because any zeroes in the assumed initial array are carried forward to the final array estimates. In Step 2 the initial migration values are adjusted by the ratio of the OAS totals to the relevant sum of migration elements to ensure that the estimates are OAS-consistent. The Step 2 values pass to Step 3 where they are similarly adjusted to be DAS-consistent, and Step 3 values pass on to Step 4 where they are factored to be OD-consistent.

Figure 4. The iterative proportional fitting routine to estimate ODAS migration flows in Britain, 1975-76 to 1982-83

Target variable to be estimated:
M(i,j,a,s) = migrations from origin i to destination j, by persons in age a and sex s.
Information known:
M(i,j) = migrations from origin i to destination j
O(i,a,s) = total out-migrations from origin i in age group a and sex s = $_{j}$ M(i,j,a,s)
D(j,a,s) = total in-migrations to destination j in age group a and sex s = $_{i}$ M(i,j,a,s)

Repeat Steps [0] to [5] for all periods and sexes

Step [0]: check that the sub-arrays add to the same total

Does $_{i,a,s}$ O(i,a,s) = $_{j,a,s}$ D(j,a,s) = $_{i,j}$ M(i,j)?
If not, resolve the difficulty before proceeding.

Step [1]: define the initial values

For all i, j and a
M(i,j,a,s)[1] = 1

Step [2]: adjust to known origins by age

M(i,j,a,s) [2] = M(i,j,a,s)[1] {O(i,a,s)/ $_{j}$ M(i,j,a,s)[1]}

Step [3]: adjust to known destinations by age

M(i,j,a,s)[3] = M(i,j,a,s)[2] {D(j,a,s)/ $_{i}$ M(i,j,a,s)[2]}

Step [4]: adjust to known origin-destination flows

M(i,j,a,s)[4] = M(i,j,a,s)[3] {M(i,j)/ $_{a,s}$ M(i,j,a,s)[3]}

Step [5]: check for convergence

D= abs{M(i,j,a,s)[4] - M(i,j,a,s) [1]}

If all D < ½,
then stop the process and write out M(i,j,a,s)[4]
else
s*et al*l M(i,j,a,s)[1] = M(i,j,a,s)[4} and return to Step 2.

At Step 5 a check is made for convergence of values by computing the absolute differences between Step 1 and Step 4 values for each element of the SODA array. The test criterion was set to a half, which, if satisfied, ensures that the rounded result does not change further between iterations. If the test criterion is not satisfied, the Step 1 values are refreshed with the Step 4 results and a new iteration is effected. Normally, convergence is achieved within 10 iterations. Many cells will contain small fractional numbers but these will be aggregated when the single years used for the IPF routine are assembled into the five year periods required for the harmonised database.

4. CONSTRUCTING TEMPORALLY CONSISTENT REGIONS

Two spatial aggregations were performed in preparing the harmonised databases for Australia and Britain. These were: (1) defining temporally consistent building blocks, and (2) aggregating those building blocks into city regions. The first process was carried out in different situations in the two countries. In Australia the first aggregation (to TSDs) was performed by ABS in preparing the requested special tables, but TSDs had first to be defined. In Britain the first aggregation was performed on the standard files assembled into the TIMMIG database and combined with the second aggregation into harmonised regions. This section of the paper describes the first aggregations.

4.1 Defining Temporally Consistent Regions, Australia, 1976-96

A common problem that confronts time series analysis of Census and other demographic data is change in the boundaries of spatial units. In Australia, information on usual residence, which form the basis for migration flow matrices, is coded to Statistical Local Area (SLA) level. SLAs consist of a single local government area (LGA) or part thereof. Derivation of a regional framework for migration analysis over the four intercensal periods 1976-81 to 1991-

96 therefore required identification of regions each comprising one or more whole SLAs with a common outer boundary.

The approach adopted for this project builds on the Statistical Division (SD) level of the Australian Standard Geographic Classification (ABS, 1996). SDs were designed to be large… ‘relatively homogeneous regions characterised by identifiable social and economic links between the inhabitants and between the economic units in the region, under the unifying influence of one or more major towns or cities’ (ABS, 1992). They were first introduced in the 1966 Census and were expected to remain unchanged for a period of 20-30 years. In practice, however, some amalgamations and numerous boundary changes have occurred over this period. At the 1996 Census there were 58 SDs (excluding the newly defined ‘Other Territories’ and various special purpose codes), each representing a defined, identifiable geographic area. The capital city in each state or territory is represented by a single SD and the non-metropolitan parts of the six states were split into a variable number of SDs, ranging from eleven in New South Wales to three in Tasmania.

The problems and issues involved in constructing a temporally consistent set of zonal boundaries are discussed by Blake *et al*. (2000) who identify four main approaches to establishing temporally consistent geographies: freezing history; updating to contemporary zones; constructing designer-zones; and geo-referencing. This project adopted the designer-zone solution which involves the construction of purpose-built zones from smaller building blocks so as to harmonise the zonal systems from various Censuses on a common set of boundaries. The task then is to find the best fit to optimise specified criteria. The procedures adopted are set out in Blake, *et al*. (2000). To summarise: Geographical Information System (GIS) spatial overlay techniques were used to compare SD and SLA boundaries at each of the four Censuses from 1981 to 1996; visual comparisons were made to identify boundary changes; and a heuristic procedure was used to search for the best set of temporally consistent boundaries while minimising the overall departure from the functional structure of the SD system. Four main principles were adopted to guide this search and adjustment procedure:

- As far as possible the SD boundaries from the latest (1996) census were adopted as the standard and earlier boundaries adjusted to match. This was possible only where the change was confined to the transfer between SDs of one or more compete, pre-existing SLAs.
- SD boundaries for earlier Censuses were adopted when the 1996 boundary did not provide a viable option. This could occur, for example, if the 1996 SD boundary was shifted to encompass a newly created SLA.
- Where none of the SD boundaries provided consistency, the nearest temporally coincident SLA boundaries were adopted. If more than one option was available, the choice was made so as to minimise the aggregate deviation, in terms of total population, from the 1996 SD boundary.
- Where minor realignments had been made to SD boundaries involving part SLAs with comparatively small geographic areas, the size of the population involved was estimated. If the population in the realigned area represented less than one per cent of the aggregate population of any of the affected SDs, the inconsistency was accepted: that is, no realignment was made.

Australia is highly urbanised and together the five SDs which cover the capital cities in the mainland states account for almost 60 per cent of the total population. Leaving these as five single regions would therefore mask a considerable proportion of total internal migration. It would also obscure one of the key dimensions of migration within Australia – the movements between inner, middle and outer suburban areas. In order to capture this type of movement, each of the five capital city SDs was split into three concentric zones differentiating inner, middle and outer suburbs. In each case, these were defined by reference to SLA boundaries and designed to be consistent with definitions adopted by land use planning agencies in the various States.

The result of this analysis is a set of 69 TSDs which for practical purposes are spatially consistent over the 1981, 1986 1991 and 1996 Censuses. These are mapped in Bell *et al*. (1999) and in Blake *et al*. (2000). While complete comparability is out of reach in work such as this, the residual discrepancies between TSDs are small, at least in terms of population. Defining these TSDs are four concordance or look-up tables, one for each census year, which list the SLA codes and the code of the TSD to which they were assigned.

4.2 Defining Temporally Consistent Regions, Britain, 1976-96

Apart from very minor changes, the boundaries of the spatial units used in the NHSCR migration counting system remained remarkably stable over the 20 year period 1976-1996. In England and Wales the spatial unit was the Family Health Service Authority area, while in Scotland it was the Area Health Board (AHB). In Northern Ireland Health Board Areas also exist but are not used in the NHSCR migration statistics. The period of interest is sandwiched between a major local government and health area re-organization, which took place in 1974-75 and another which took place in 1996-98 (see Wilson and Rees, 1999a, 1999b). There are, however, two major exceptions, which forced us to carry out some aggregations.

In the 1976-83 period, statistics for migration flows between AHBs in Scotland are available, but statistics for migration flows between English or Welsh FHSAs and Scottish AHBs are missing. In the 1983-96 period these latter flows are available but not the flows within Scotland. Given these missing flows in the official data sources, a decision was taken to treat Scotland as a single zone in the system. Major investment is required by the NHS and the General Register Office Scotland to improve these statistics. The second boundary change that necessitated some aggregation involved FHSAs in London. Before 1983, the West

London FHSAs of Barnet, Hillingdon, Brent-Harrow and Ealing-Hammersmith-Hounslow were combined as the Middlesex Family Practitioner Committee (FPC). To maintain consistency through the 20-year period, therefore, statistics from mid-1983 forwards were aggregated into a Middlesex zone. A map of the 96 FHSAs and the corresponding 69 TSDs is provided in Bell *et al*. (1999).

5. DEFINING FUNCTIONALLY COMPARABLE REGIONS

The 69 TSDs and 96 FHSAs provide systems of temporally consistent spatial boundaries which could be employed directly as a basis for comparing migration in the two countries. However, there are two strong arguments for further spatial aggregation. The first is the need to reduce the size of the SODA arrays in order to detect the main structure of the migration system without being overwhelmed by the geographical detail. The second argument derives from the need to compare the two countries in terms of regional systems that, as far as possible, capture both commonalities and uniqueness in the functional structure of their national space economies.

The concept chosen as the basis for aggregating TSDs and FHSAs was that of the functional city region. Cities are the organisers of national space: they house the higher order functions of government, finance for business, ownership of capital, the creation of information and its dissemination, research and development and the stimulation of innovations. They continue to dominate surrounding territory by providing jobs to commuters, markets and finance to rural industries, even though many routine activities have moved to peripheral suburbs or small towns. Cities are surrounded by zones that they organise in different ways, depending on accessibility and resources, so that the whole national territory can be divided into competing city spheres of influence. Thus, a city region framework enables us to examine the migration flows and shifts between economic regions and between zones within them differing in density and accessibility to metropolitan functions. We can rank how well city regions are doing in terms of migration attractiveness as a whole without getting misled by the way conventional administrative boundaries carve up functional geographic space.

Sophisticated methods have been developed to define such city region zones, based mainly on daily journey to work relationships (e.g. Coombes *et al*., 1983; Champion *et al*., 1986 on functional urban regions in Britain). Here we use a very simplified version of the city region building process. The assembly of TSDs and FHSAs into city regions was based on principles of contiguity and functional linkages, but was implemented through subjective knowledge rather than being performed through an objective mathematical algorithm. The procedure involved a series of steps:

- Select building block units (TSDs or FHSAs) that have large urban populations and make those city region <u>cores</u>.
- Define the adjacent urbanised areas which have close functional linkages with the cores as <u>rest</u> regions.
- Place adjoining areas into <u>near</u> regions: these are generally more distant from the cores (though they may be contiguous) but are closely connected by commuting flows.
- Allocate the next layer of building blocks to the appropriate cores, according to their transport links and migration flows. In Britain these are essentially the most non-metropolitan parts of the country and are designated <u>coastal/country</u> regions. In Australia, a further division is made between the rapidly growing <u>coastal</u> regions (located on the east coast of New South Wales and Queensland), and a set of stable or declining agricultural regions, generally located inland, termed <u>far</u> regions.
- In Australia, assign the remaining regions to the <u>remote</u> category attached to the city region core to which they are most connected. These are the 'outback' regions of

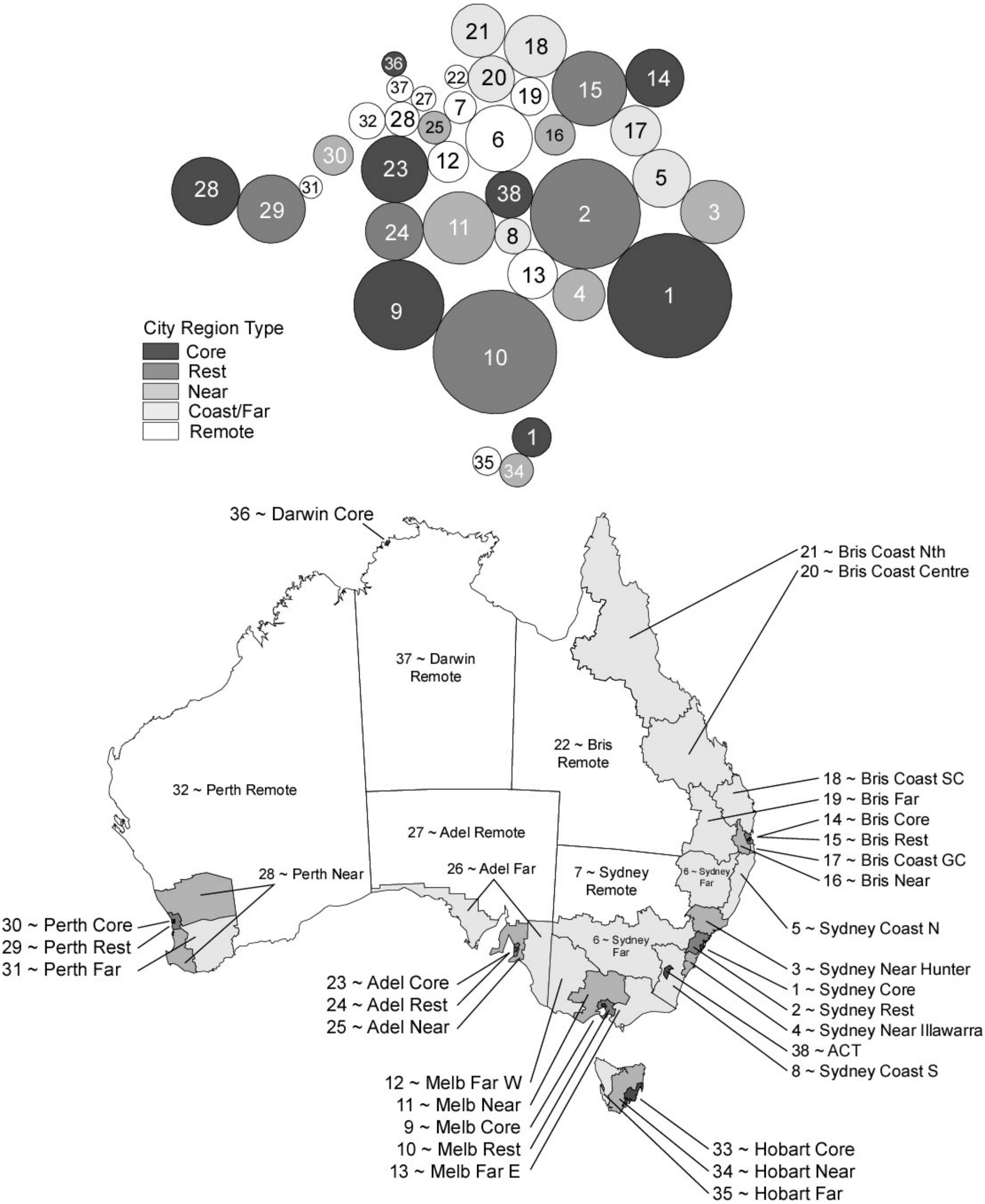
Australia for which there is no equivalent in England and Wales. In Britain, assign Scotland and Northern Ireland to a residual, other category.

In Australia, the city regions aggregate exactly to States, but they do not aggregate to countries in the UK because Wales is divided between Liverpool, Birmingham and Cardiff city regions.

5.1 City Regions in Australia

In Australia, the city-region system divides readily into eight major spheres of influence reflecting the original pattern of colonial settlement, subsequently transformed into the states and territories, each of which is dominated by its respective metropolitan centre. Thus, Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Darwin and Canberra represent the cores of a system of 38 Australian city regions, also termed ACRs**.** In the case of the mainland state capitals, the cores were defined to comprise the inner and middle suburbs TSDs while the outer rings, which include the newly urbanising periphery and inner parts of the peri-metropolitan hinterland of these cities, were classified as ‘Rest’. Elsewhere the allocation of TSDs to ACRs was structured around previous analyses of inter-regional migration flows and networks which distinguished the markedly different roles and functions of near city regions, specialised economic regions, the amenity-rich coast, the wheat-sheep belt and the outback (Bell and Maher, 1995). The resulting city-region structure is mapped in Figure 5. The map also provides a 1991 population based cartogram of the regions, developed using the Dorling (1996) algorithm. The classification can be collapsed to states and territories, to region type (city cores, rest, near, far, coast and remote) or to a metropolitan-non-metropolitan dichotomy.

Figure 5. City regions in Australia



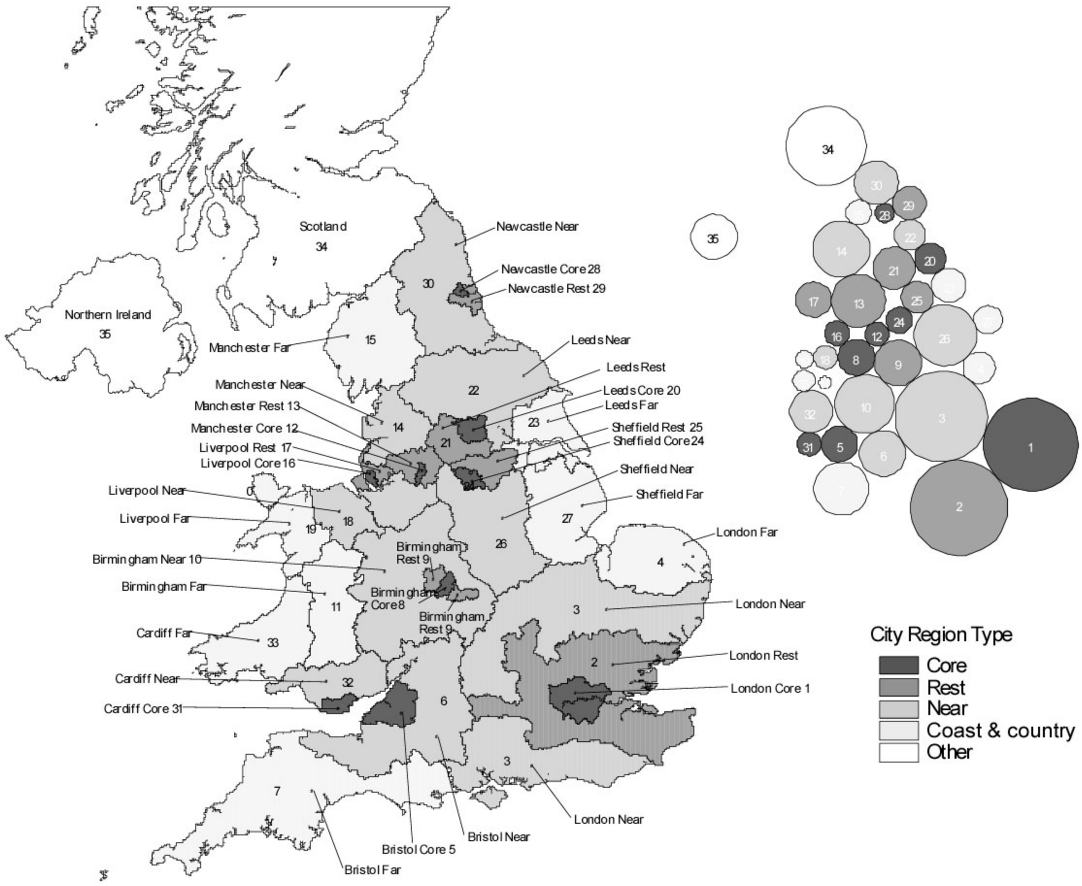
5.2 City Regions in Britain

Figure 6 maps the British city region boundaries and provides a 1991 population based cartogram. The classification recognizes 9 city regions in England and Wales (London, Bristol, Birmingham, Manchester, Liverpool, Leeds, Sheffield, Newcastle, Cardiff) plus Scotland and Northern Ireland. Each city region has a Core (usually the largest metropolitan district or its county equivalent, and a system of satellite nonmetropolitan counties classified as Rest, Near or Far. Like their Australian counterparts, the British regions can be aggregated into a number of different classifications including city regions and regional types, and into metropolitan-non-metropolitan or north-south divisions. In the following section we provide a brief illustration of the insights to be derived from comparison of the two databases using these classifications.

5.3 Migration in a City-Region Framework

Over the course of their lives Australians change residence nearly twice as often as Britons (Rees *et al.*, 2000). This difference is mantained in migration statistics for our systems of city regions: 14.7 per cent of the Australian population of 16.8 million migrated between regions at least once between 1991 and 1996 while the number of moves between city regions in Britain recorded by the NHSCR, which includes multiple moves made by the same individual, involved around 12.5 per cent of the 1991 population of 58.4 million. Inter-regional migration in Australia also displays a significantly higher level of effectiveness than is the case in Britain, bringing about a substantially larger redistribution of population between regions relative to the overall volume of migration. Elsewhere, the authors with colleagues have shown that the Migration Efficiency Index (MEI), which measures the ratio between net population redistribution and total interregional migration flows, was almost twice as large in Australia (11.1 per cent) as in Britain (6 per cent), although in both countries migration has

Figure 6. City regions in the UK



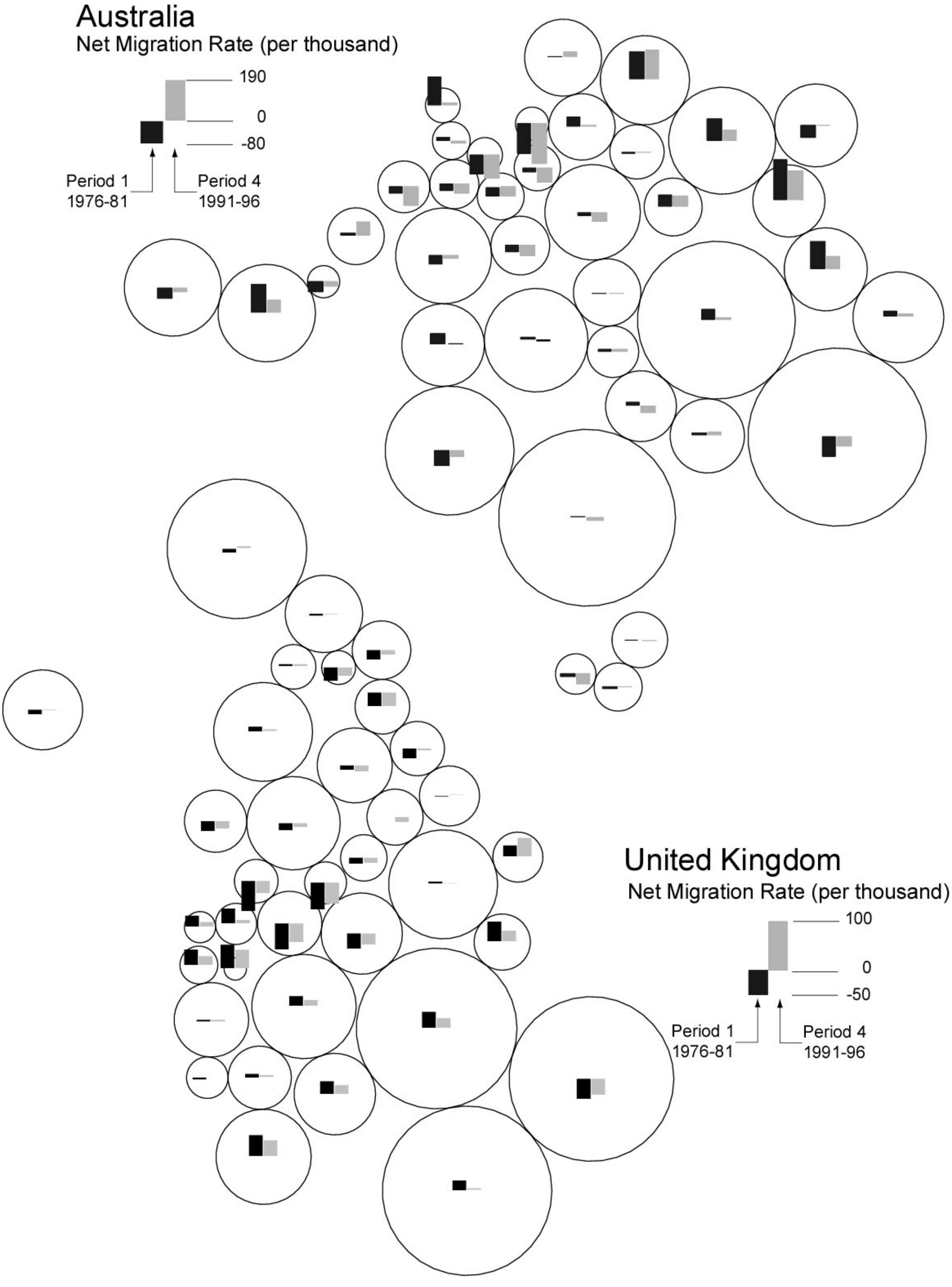
become progressively less influential as a mechanism for population redistribution over time (see Stillwell *et al*., 2000).

Despite these variations in migration intensity and effectiveness between the two countries, there are striking parallels in the patterns of net population movement which the city region systems help to reveal. These are readily apparent when the pattern of net migration rates in the two regional systems is mapped. We illustrate this for the first and last of our four five year intervals (1976-81 and 1991-96) using cartograms in Figure 7.

At the broadest scale, the contrast in Britain is between southern England, which has generally experienced net migration gains, and the northern regions, where gains have been smaller or losses have occurred. In Australia, on the other hand, the major contrast is between the east coast, whose regions have registered sustained net migration gains, and the inland and outback regions where persistent losses have been recorded. Superimposed on these broadscale shifts, a second pattern of redistribution evident in both countries is the net outmovement from city cores, and offsetting gains in adjacent nonmetropolitan and coastal regions. These similarities come into sharp focus through a systematic analysis of migration patterns in each regional type, but subtle differences also come to light:

- The urban *Cores* in both countries have principally been characterised by heavy out-migration but all cities shared a common trend towards reduced migration losses between the 1976-81 and 1991-96 periods. The outflows reflect the widespread emergence of counterurbanisation during the 1970s, shifts in family and household type, and industrial restructuring which has generated pronounced outflows from cities such as London and Manchester in Britain, and from Sydney, Melbourne and Adelaide in Australia. Reduced losses during the 1990s mirror the economic and social revitalisation of the inner cities in both countries. Bristol, Darwin and Canberra owe more positive performance to their specialised roles in their countries' space economies.

Figure 7. Net migration rates (all ages) for city regions in Australia and the UK: 1976-81 and 1991-96



- *Rest* regions in the two countries registered quite different outcomes, with gains in Australia but losses in Britain. This variation reflects marked differences in the settlement pattern of the two countries: in Britain rest regions are dominated by older industrial towns still undergoing economic restructuring whereas in Australia they encompass the post-war metropolitan suburbs with more viable local economies and fringe housing opportunities.
- *Near* regions take their migration gains from major cities and have been a major focus for counterurban migration since the 1970s. While these regions have attracted sustained net migration gains over the two periods in both countries, local economies are beginning to reach maturity and the epicentre of growth has now moved to more attractive settlements in *Coast* and *Coast and Country* regions beyond.
- *Coast* (Australia) and *Coast and Country* (Britain) regions gained heavily in both periods, reflecting the shift to a services economy, and the rise of consumption-led migration, especially among retirees. The attraction of climate, beaches and scenery is more pronounced in Australia, especially in coastal Queensland and New South Wales (Sydney North and South Coasts, Brisbane Gold and Sunshine Coasts) than in their counterparts in Britain (Bristol Far - the South West peninsula; Birmingham Far - Mid-Wales, and London Far - the Norfolk coast), but the underlying forces are the same.
- *Far* and *Remote* regions in Australia have no equivalents in Britain but both types of region experienced increasing rates of net migration loss over the two periods. Out-migration of young adults from the limited job opportunities available in rural areas and small towns has been a persistent feature of rural Australia but this has accelerated since the late 1980s with deteriorating terms of trade, farm amalgamation, recurrent drought, the widespread withdrawal of services and the progressive economic decline of older industrial towns.
- In Scotland and Northern Ireland (classified in the *Other* region type in Britain) migration flows from core to rest, rest to near, and near to coast also occur at a smaller spatial scale, not

captured in this macro-analysis. In aggregate, however, these regions display the reverse of the declining performance of the Australian outback: Scotland reversed its losses of the 1970s to register a migration gain in the 1991-96 interval while in Northern Ireland the rate of net outflow was cut by an order of magnitude to a little over 0.1 per cent.

6. HARMONISING THE AGE-TIME PLANS FOR THE MIGRATION DATA

The final task in preparing the two migration databases for comparative analysis is to harmonise age-time plans. The procedures used are complex though the principles are straightforward. A full account is given in Bell *et al*. (1999) and in Bell and Rees (2000).

Why is it essential to convert both data sets to a full APC classification? The answer is because that is the only way that data assembled under a period-cohort observation plan can be reliably compared with data from a period-age plan. When five-year age and time intervals are used, there is considerable difference between measures under the two observation plans. If age-specific migration measures from one country computed using period-cohort data are compared with those from another country using period-age data, real differences between the two situations cannot be distinguished from the artefactual variations resulting from the different age-time observation plans.

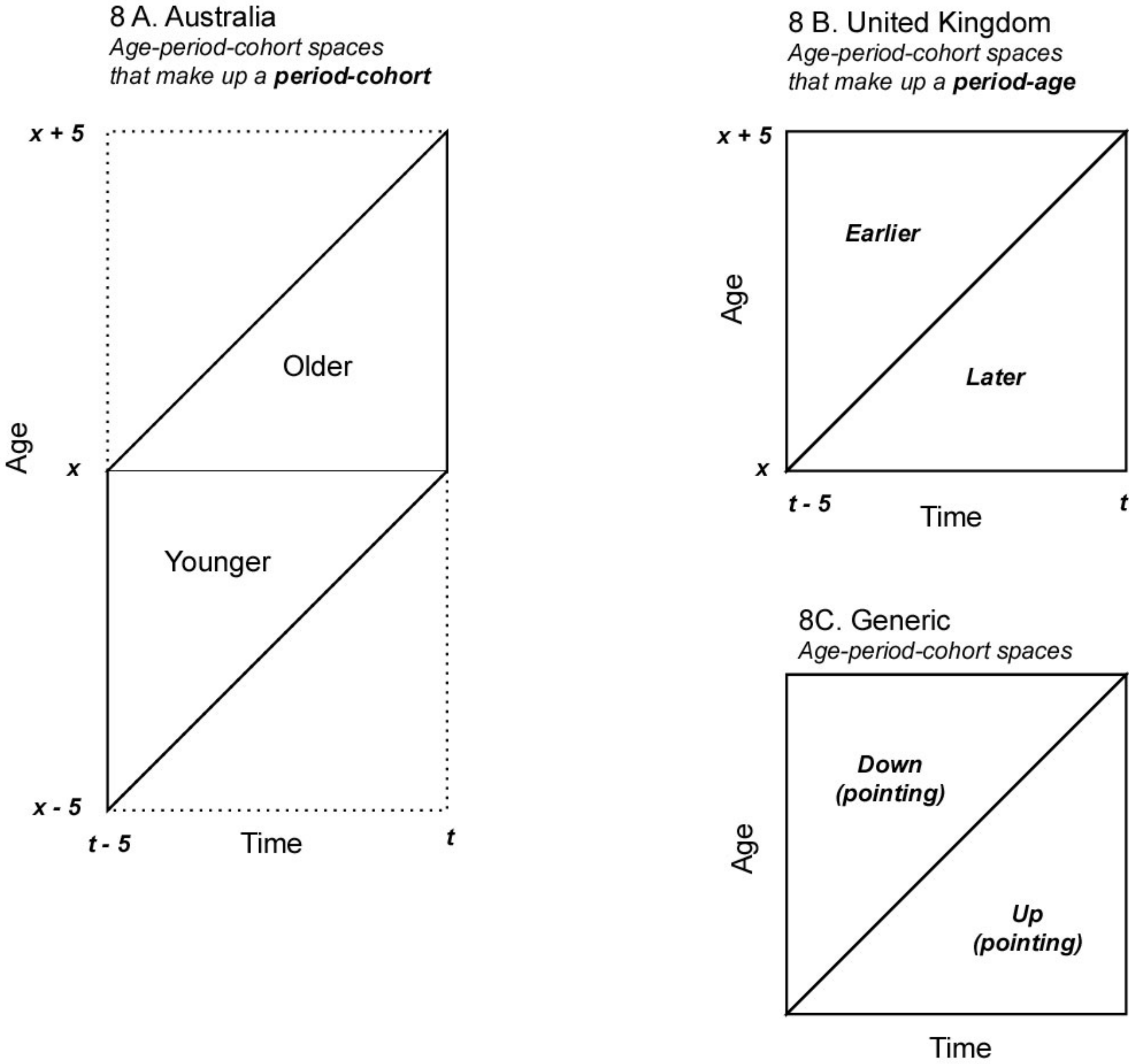
It should be noted that the estimation routine outlined below to convert movement data to APC spaces is only a substitute for better data than could be generated at source. For example, the NHSCR movement data in person unit record form could have been doubly classified because date of birth and date of move are known. However, this information was not available for the 1976-83 period (Duke-Williams and Stillwell, 1999). Migration data classified by age at time of migration cannot be generated from census data unless the right question is asked, so direct generation of the APC migrant data was not possible for Australia.

The target aim is that all migration flows are classified by age, period and cohort simultaneously, so that when migration measures are computed the calculations can be made for comparable APC spaces. Figure 8 shows three age-period-cohort diagrams that illustrate what is involved. Figure 8A, which applies to the Australian data, shows how a period-cohort space is made up of two APC triangles aligned on top of each other. Figure 8B, which applies to the British data, shows how the period-age space is also composed of two APC triangles, aligned next to each other. In the first case, the APC spaces are naturally labeled “younger” and “older”, referring to the assumed age at which migration takes place. In the second diagram, the APC spaces are naturally labelled “earlier” and “later”, referring to the timing of the birth cohorts that contribute to each APC space. Because we use both views of the data confusion can develop. A more generic terminology is described in Figure 10C, which defines the two APCspaces as “down” and “up”, labels that remain constant over different age-period plans. “Down” means that the triangle points downwards from the horizontal, while the “up” triangle points upwards.

6.1 Disaggregating the Australian Migration Data into Age-Period-Cohort Flows

Creating the Australian database requires that the period-cohorts, in which Australian census data are naturally reported, be decomposed into the older age (up) and younger age (down) APC spaces. One option would be to divide each period-cohort group into equal parts. However, mobility rates vary markedly by age and this approach would radically overstate the volume of movements occurring in some age groups and understate them in others. For example, data for a single year migration interval indicate that mobility rates climb sharply to peak at around age 23. Consider, then, the movement of the cohort aged 20-24 at time t. This high mobility group were aged 15-19 at time t-5 but the bulk of the movement recorded

Figure 8. Frameworks for age-period-cohort processing of Australian and UK migration data



among this group almost certainly occurred at older ages: that is in the 'Up' triangle of the period-cohort space.

In order to capture these variations, the period-cohort data for each inter-regional flow were divided between APC spaces using a set of separation factors derived from national mobility profiles for single year intervals classified by sex and single years of age. Age-sex profiles of movement between SDs were acquired from ABS for the single year intervals 1975-76, 1980-81, 1985-86 and 1995-96, and converted to conditional migration probabilities [movers/(movers+non-movers)] . Probabilities for intermediate years were then derived by linear interpolation. The interpolation procedure was extended to ten years between the 1985-86 and 1995-96 intervals because no sub-state migration data were collected at the 1991 Census. This procedure delivers a matrix of migration probabilities by sex and single years of age from age 1 to age 99 and over (age measured at the end of the interval) by single year intervals from 1975-76 to 1995-96. Separation factors for each period-cohort in each interval were then derived by summing the appropriate propensities in each APC segment of the period-cohort space and expressing each sum as a proportion of the whole. Period-cohort probabilities at the horizontal margin of the two APC spaces were split between segments as weighted averages of the probabilities in the adjacent period-cohorts.

The single year of age migration profiles also provide a mechanism for estimating the number of transitions occurring in the youngest APC space: that is to the cohort who were aged 0-4 at the time of the Census, having been born during the preceding five year interval. Since this group were not alive five years previously, Censuses generally do not collect information on their movements. However, some estimate of the transitions made by this group is needed to match the corresponding figure from the British NHSCR database, since the latter records information about migration at all ages, including among infants. The solution adopted here was to estimate the number of transitions in this space by applying a multiplier to the number occurring to the immediately older period cohort (ie those aged 5-9 at the Census) during the same interval. The multipliers were derived in the same way as the separation factors described above, that is by summing the appropriate propensities from the national single year of age migration profiles and comparing the results for the two cohorts.

6.2 Disaggregating the British Migration Data into Age-Period-Cohort Flows

In Britain, the NHSCR migration statistics are reported by period-age, which must be disaggregated into the earlier cohort (down) and later cohort (up) APC spaces. In this case the procedures are complicated by variations in the extent of disaggregation in the available data. The 1976-77 to 1982-83 files classify migration by five-year age groups, whereas in the 1983-84 to 1995-96 files it is classified by single years of age. To estimate migration flows for each age-period-cohort space, slightly different schemes are needed for each five-year time interval. In 1976-81 only five year age group data are input; in 1981-86 both five year and single year of age data are input; for 1986-91 and 1991-96 only single year of age data are input. We consider the 1976-81 case first, then the 1986-91 and 1991-96 cases, and finally the procedures for 1981-86 where there is a mixture of data.

The method for the period 1976-81 involved summing the five-year period-age counts for single years to a five year total, using weights that varied with the position of the year in the sequence. So, nine-tenths of a period-age migration count for the first year is assigned to the down APC element and one-tenth to the up APC element. For the second year the corresponding fractions are seven-tenths and three-tenths. The sequence continues five-tenths/five-tenths for year 3, three-tenths/seven-tenths for year 4 and one-tenth/nine-tenths for year five. The implicit assumption is that migration events are evenly distributed within a five-year period-age observation for a single year.

For the periods 1986-91 and 1991-96 we have migration data for single years of age and time. Most of these observations the period-age counts can be assigned directly to a five-year APC element. For those period-age counts straddling the diagonal separating up and down APC elements, we simply assume that half the migrations occur in the up APC element and half in the down.

For the period 1981-86 we must combine the two estimation methods, using the five year age group information for the first two years (1981-82 and 1982-83) and the single year method for the last three years (1983-84, 1984-85, 1985-86).

The method for the last APC element is slightly different. The methods described above are applied to period-ages 0-4 to ages 65-69. The final APC space, 70-74 to 75+, is an open-ended trapezium. We add the migrations of the down APC for ages 70-74 to all migrations for age 75+.

6.3 Illustrations

Tables 1 and 2 show the results of the age-period-cohort disaggregation procedures. Table 1 contains migration flows between city regions for period-cohorts, age-period-cohorts and period-ages in 1991-96 for Australia, while Table 2 displays parallel flows for period-ages, age-period-cohorts and period-cohorts for Britain. In both tables the left hand sub-table contains the summary migration flows derived from the source data; the middle sub-table shows those counts broken down into age-period-cohort elements; the rightmost sub-table shows the counts re aggregated into the target age-time plan. Without going through the age-time plan disaggregation, we would be forced to compare Australia's period-cohort data with Britain's period-age data. With the harmonised database, we can compare Australian or British data using either the period-cohort or the period-age plan.

Table 1. Migration flows between city regions for period-cohorts and age-period-cohorts and period-ages, 1991-96 for Australia

SOURCE DATA			
Age at start of interval	Age at end of interval	Period-cohort code	Migration between city regions i,n 1991-96
Birth	0-4	1	128,704
0-4	5-9	2	205,157
5-9	10-14	3	166,765
10-14	15-19	4	176,478
15-19	20-24	5	294,127
20p-24	25-29	6	328,277
25-29	30-34	7	278,823
30-34	35-39	8	228,028
35-39	40-44	9	169,217
40-44	45-49	10	136,429
45-49	50-54	11	96,394
50-54	55-59	12	76,168
55-59	60-64	13	60,917
60-64	65-69	14	52,859
65-69	70-74	15	36,761
70+	75+	16	54,003
Total		*	2,489,107

INTERMEDIATE DATA			
Age group at migration	Birth cohort	Age-period-cohort code	Migration between city regions in 1991-96
0-4	1991-96	1	128,704
0-4	1986-91	2	114,810
5-9	1986-91	3	90,347
5-9	1981-86	4	88,112
10-14	1981-86	5	78,653
10-14	1976-81	6	72,677
15-19	1976-81	7	103,801
15-19	1971-76	8	119,191
20-24	1971-76	9	174,936
20-24	1966-71	10	176,329
25-29	1966-71	11	151,948
25-29	1961-66	12	155,458
30-34	1961-66	13	123,365
30-34	1956-61	14	125,650
35-39	1956-61	15	102,378
35-39	1951-56	16	91,327
40-44	1951-56	17	77,890
40-44	1946-51	18	71,766
45-49	1946-51	19	64,663
45-49	1941-46	20	49,677
50-54	1941-46	21	46,717
50-54	1936-41	22	38,581
55-59	1936-41	23	37,587
55-59	1931-36	24	30,634
60-64	1931-36	25	30,283
60-64	1926-31	26	26,716
65-69	1926-31	27	26,143
65-69	1921-26	28	18,145
70+	1921-26	29	18,616
70+	pre1921	30	54,003
Total	*	*	2,489,107

TRANSFORMED DATA		
Age group at migration	Period-Age Code	Migration between city regions in 1991-96
0-4	1	243,514
5-9	2	178,459
10-14	3	151,330
15-19	4	222,992
20-24	5	351,265
25-29	6	307,407
30-34	7	249,014
35-39	8	193,705
40-44	9	149,656
45-49	10	114,340
50-54	11	85,298
55-59	12	68,221
60-64	13	56,998
65-69	14	44,289
70+	15	72,619
Total	*	2,489,107

Table 2. Migration flows between city regions for period-ages, age-period-cohorts and period-cohorts, 1991-96 for the UK

SOURCE DATA

Age group at migra-tion	Period-Age Code	Migration between city regions in 1991-96
0-4	1	500,668
5-9	2	365,109
10-14	3	295,033
15-19	4	871932
20-24	5	1,496,696
25-29	6	1,132,022
30-34	7	744,864
35-39	8	454,874
40-44	9	315,269
45-49	10	264,184
50-54	11	187,256
55-59	12	152,711
60-64	13	139,384
65-69	14	119,732
70+	15	313,393
Total	*	7,353,127

INTERMEDIATE DATA

Age group at migratio n	Birth cohort	Age-period-cohort code	Migration between city regions in 1991-96
0-4	1991-96	1	248,299
0-4	1986-91	2	252,369
5-9	1986-91	3	194,307
5-9	1981-86	4	170,802
10-14	1981-86	5	149,935
10-14	1976-81	6	145,099
15-19	1976-81	7	287,294
15-19	1971-76	8	584,639
20-24	1971-76	9	750,900
20-24	1966-71	10	745,796
25-29	1966-71	11	597,000
25-29	1961-66	12	535,022
30-34	1961-66	13	410,256
30-34	1956-61	14	334,609
35-39	1956-61	15	247,955
35-39	1951-56	16	206,919
40-44	1951-56	17	163,268
40-44	1946-51	18	152,001
45-49	1946-51	19	142,528
45-49	1941-46	20	121,656
50-54	1941-46	21	101,968
50-54	1936-41	22	85,288
55-59	1936-41	23	80,989
55-59	1931-36	24	71,722
60-64	1931-36	25	71,437
60-64	1926-31	26	67,948
65-69	1926-31	27	63,400
65-69	1921-26	28	56,333
70+	1921-26	29	49,904
70+	pre1921	30	263,489
Total	*	*	7,353,127

TRANSFORMED DATA

Age at start of interval	Age at end of interval	Period-cohort code	Migration between city regions in 1991-96p
Birth	0-4	1	248,299
0-4	5-9	2	446,676
5-9	10-14	3	320,737
10-14	15-19	4	432,392
15-19	20-24	5	1,335,539
20p-24	25-29	6	1,342,796
25-29	30-34	7	945,278
30-34	35-39	8	582,564
35-39	40-44	9	370,187
40-44	45-49	10	294,529
45-49	50-54	11	223,624
50-54	55-59	12	166,277
55-59	60-64	13	143,159
60-64	65-69	14	131,347
65-69	70-74	15	106,237
70+	75+	16	263,489
Total	*	*	7,353,127

6.4 Deriving Populations at Risk

In order to compute intensities of migration, it is necessary to match migration flow counts with populations at risk. Appropriate population stocks must be used to compute transition probabilities or occurrence-exposure rates. This is not quite as straightforward as it sounds but space prevents full discussion here. Rees *et al*. (2000) discuss the transition case in detail, while Bell *et al*. (1999) provides a full account of the population at risk equations. You need population stocks at the start and end of each period to construct occurrence-exposure or movement populations at risk. For transition probabilities, the start population is most appropriate but when census data are used it is appropriate, for reasons explained in Rees *et al*. (2000) to use a particular transformation: people who survived and remained within the country at the end of the period, as measured by the the end of period census, but recorded at their origin at the start of the period.

7. CONCLUSIONS

If the history of fertility and mortality research provides a reliable guide, understanding of the dynamics of internal migration will be aided by two key forms of research: longitudinal analyses which enable the relative influence of age, period and cohort effects to be disentangled; and cross-national studies which place the phenomenon in a range of spatial contexts. Neither type of study is in plentiful supply, but research which combines both dimensions is particularly scarce. This can be traced, at least in part, to the difficulties of assembling the requisite data.

This paper has examined the issues involved in the construction of harmonised data bases of internal migration and set out the basic steps needed for two countries that are ostensibly similar in their socio-political traditions, if not in their physical geography. The main burden of the paper is to underline the need for care and rigour when when handling superficially similar data. We identified four key dimensions in which such datasets need to be harmonised. These relate to: the conceptual basis on which migration is measured; the time periods over which it is recorded; the system of spatial zones between which the moves are registered; and the age-time plan from which the movement is observed.

There is no simple basis by which to convert event data to transitions, or *vice versa*, and in the case of Australia and Britain the discrepancies arising from these differences in the way migration is measured in the census and in population registers can only be accepted. Harmonisation is possible on the other three dimensions, but the task is by no means straightforward. It calls for the understanding of complex demographic and geographic concepts, the application of these principles to develop solutions targeted to the strengths, limitations and idiosyncracies of the local context and data sources, the development of purpose-written software to implement these solutions, and the exercise of fastidious attention to detail in carrying out the computations. These tasks, in turn, call for a wide range of skills.

The benefit to be drawn from the construction of such harmonised datasets lies in the facility it provides to make comprehensive, reliable comparisons of the dynamics, causes and consequences of internal migration in different countries, free from the uncertainties created by variations in time intervals, zonal systems and observation plans. Together with our co-researchers on this project we have argued elsewhere that such comparisons have a number of advantages: they offer a more meaningful context within which to interpret research findings; they assist in differentiating patterns and processes that are unique to a country from those that are more generally applicable; they provide a more rigorous test bed for migration theorisation; they may also lead to greater rigor and consistency in empirical research on individual countries and regions (Bell *et al*., forthcoming). That paper also identified four key dimensions on which such comparisons might be made and suggested a series of appropriate measures for each. The construction of the database described here provides the foundation for such comparisons and a series of papers utilising this unique dataset are now in preparation, focussing on overall trends in migration intensity (Rees *et al*., 2000), the response of migration to the effects of distance (Stillwell *et al*., in preparation), migration connectivity between regions (Stillwell and Bell, in preparation), and the impact of migration on population change (Stillwell *et al*., 2000 and forthcoming).

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