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AN AGE-PERIOD-COHORT DATA BASE OF INTER-REGIONAL MIGRATION IN AUSTRALIA AND BRITAIN, 1976-96

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Abstract

This paper describes the way in which parallel databases of inter-regional migration flows for Australia and Britain, classified by five year ages and birth cohorts for four five year periods between 1976 and 1996. The data processing involves estimation of migration data for comparable spatial units, the reduction of the number of those units to a reduced set for ease of analysis, the extraction of migration data from official data files supplied by the Australian Bureau of Statistics and the Office for National Statistics, and the filling of gaps in these files through iterative proportional fitting for some of the British data. The final stage in preparation of the migration databases was to estimate the numbers of transitions (Australia) or movements (Britain) for age-period-cohort spaces. In principle, this last estimation involves a fairly simple interpolation or aggregation of age-time classified migration data, but in practice a great deal of detailed attention is required. A final section specifies the populations at risk to be used for each age-period-cohort observation plan to compute migration intensities.

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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 behavior, 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 possible to track changes over time in age-specific migration intensities and to analyze the influence of the life course, secular trends and birth cohort size on these intensities.

This paper sets out the procedures for constructing parallel APC databases for Australia and Britain[1] as part of a project comparing inter-regional migration in the two countries. We set out technical details of age-period-cohort (APC) databases of interregional migration for Australia and Britain covering the period 1976 to 1996. The databases were developed as part of a collaborative project to compare internal migration in Australia and Britain in an APC framework. The project was undertaken by the School of Geography at the University of Leeds and the Department of Geographical and Environmental Studies at the University of Adelaide with parallel funding from the ESRC in Britain and the ARC in Australia.

The project required construction of comparable databases of inter-regional migration in Australia and Britain covering similar time periods and disaggregated by like age intervals and sex. As indicated in other outputs from the project, complete comparability is presently out of reach in work such as this. 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. Notwithstanding these differences, preliminary investigations indicated that it is possible to assemble comparable time series for the two countries covering the twenty year interval 1976 to 1996, disaggregated by sex and five year age groups from 0-4 to 70 and over. Nevertheless, considerable work was required in both countries to assemble the data on an APC basis.

The British migration statistics refer to *movements*. It is possible for an individual to make more than one migration in a time interval of recording. By contrast, the Australian migration statistics refer to *transitions* between locations between two fixed points in time. 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.

1.2 The Australian migration statistics

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

[1] The terms Britain and United Kingdom are used interchangeably in the paper to refer to the United Kingdom of Great Britain and Northern Ireland. Great Britain refers to the combination of England, Wales and Scotland.

level, usual address has been coded to Statistical Local Area (SLA) or (prior to 1986) Local Government Area (LGA) level. 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.

1.3 The British migration statistics

In the United Kingdom decennial censuses since 1961 have asked migration questions, but they cover only one year in the decade. Since 1975 the Office for National Statistics (formerly the Office for Population Censuses and Surveys) has published migration statistics for each quarter based on the National Health Service Central Register (NHSCR), which records 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). Currently, the FHSAs are being merged into the Health Areas authorities, which procure patient services within the NHS. A full account of the NHSCR migration statistics is provided in Duke-Williams and Stillwell (1999). The quarterly NHSCR inter-FHSA migration statistics are assembled into five year (mid-year to mid-year) periods to parallel the Australian time series.

The NHSCR migration statistics are not quite comprehensive. They do not measure migration within FHSA area; they undercount migrations by young males adults who may migrate several times before registering; 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; Stillwell, Rees and Duke-Williams 1996). More recently, the Office for National Statistics has been developing an alternative system for deriving migration statistics by comparing addresses on register downloads one year apart (ONS 1999).

1.4 Age, time, cohort definitions

The end product are databases of inter-regional migration flows for two sexes classified by 15 five year age groups (0-4 to 70+ 75+), 4 five-year periods (1976-81, 1981-86, 1986-91, 1991-96) and 19 five year birth cohorts (before 1906 to 1991-96). Table 1 gives the age, period and cohort definitions used in both the Australian and British databases. The data consist of origin-destination flow counts for males and females by age, period and cohort. Figures 1, 2 and 3 display these code definitions on age-time diagrams, conventionally refered to as Lexis diagram (see Vanderschrick 1993 for its history). It is also useful for computational convenience in analysis to add explicit codes for period-cohort and age-period-cohort. These are combinations of the three age, period and cohort codes and so do not give new information. These additional codes are listed in Table 2 and Figures 4 and 5 show the codes in age-time plans.

Assembling these data into an age-period-cohort framework involved a number of tasks:

- definition of a consistent set of spatial regions covering the four periods.
- definition of a reduced set of regions for the APC analysis.
- acquisition and processing of migration flow matrices on these boundaries from the Australian Bureau of Statistics and the Office for National Statistics respectively.
- processing into age-period-cohort flows of the period-cohort flow data from the Census (Australia) or of the period-age flow data from the NHSCR (United Kingdom).
- estimation of the population ‘at risk’ of migration in each period-age, period-cohort and age-period-cohort group in the transition case (Australia) or the movement case (Britain).

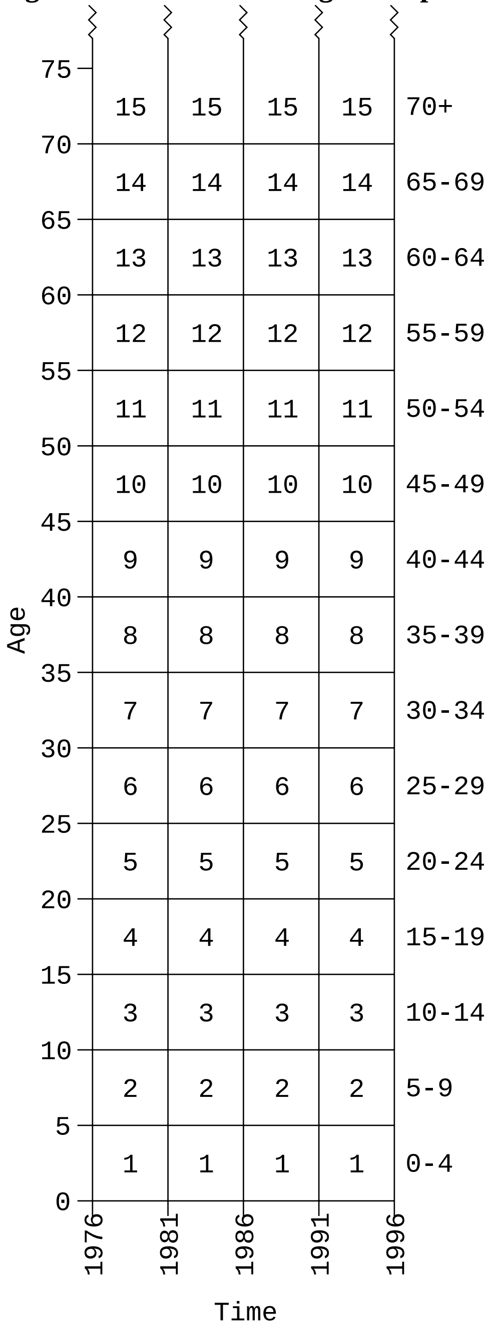
The following sections describe the procedures adopted for each of these tasks.

Table 1: Codes for ages, periods, birth cohorts and sex

Age group	Age Code	Period years	Period Code	Birth cohort years	Birth cohort code	Sex	Code
0-4	1	1976-81	1	Born before 1906	1	Males	1
5-9	2	1981-86	2	Born 1906-11	2	Females	2
10-14	3	1986-91	3	Born 1911-16	3		
15-19	4	1991-96	4	Born 1916-21	4		
20-24	5			Born 1921-26	5		
25-29	6			Born 1926-31	6		
30-34	7			Born 1931-36	7		
35-39	8			Born 1936-41	8		
40-44	9			Born 1941-46	9		
45-49	10			Born 1946-51	10		
50-54	11			Born 1951-56	11		
55-59	12			Born 1956-61	12		
60-64	13			Born 1961-66	13		
65-69	14			Born 1966-71	14		
70+	15			Born 1971-76	15		
				Born 1976-81	16		
				Born 1981-86	17		
				Born 1986-91	18		
				Born 1991-96	19		

Note: In the UK database we also hold populations for the ages 70-74 which can be used to derive the 75+ populations (as wee also have the 70+ populations) when required by some population at risk calculations

Figure 1 & 2: Codes for ages and periods



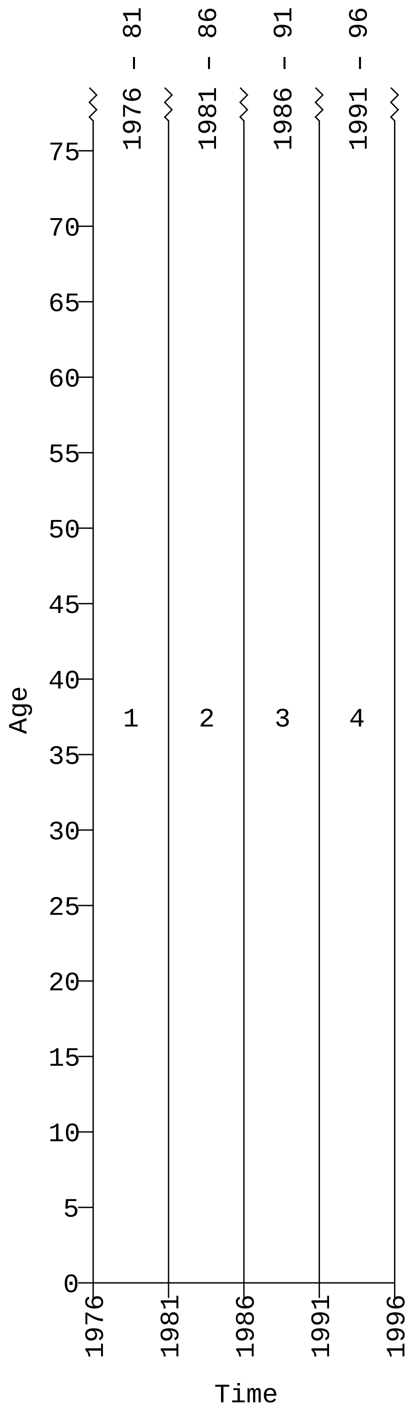


Figure 3: Codes for birth cohorts

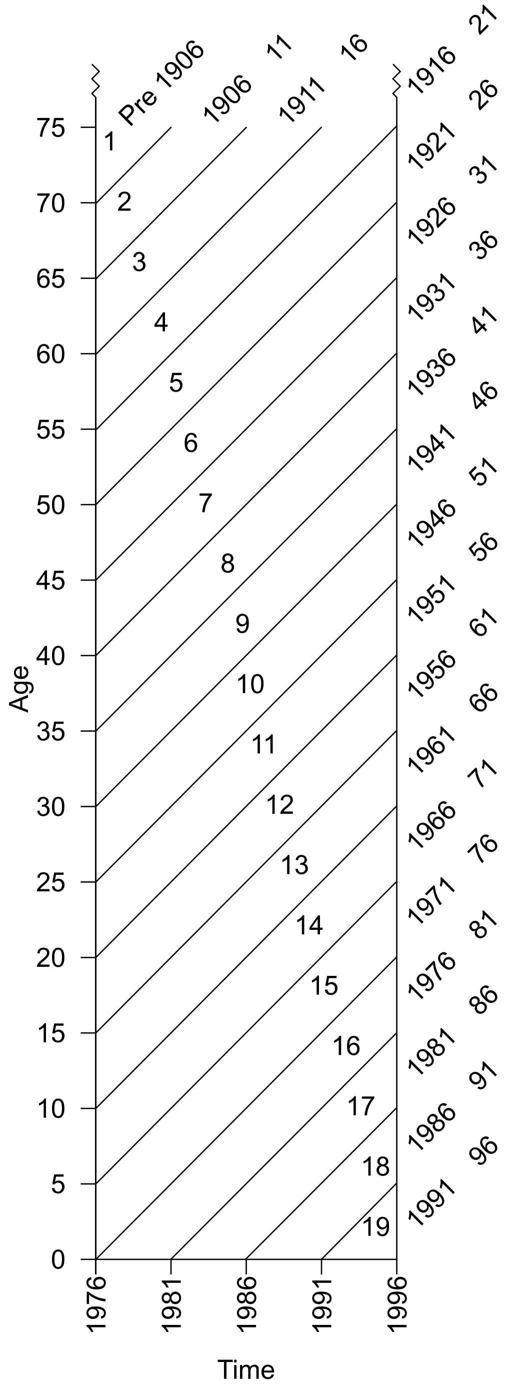
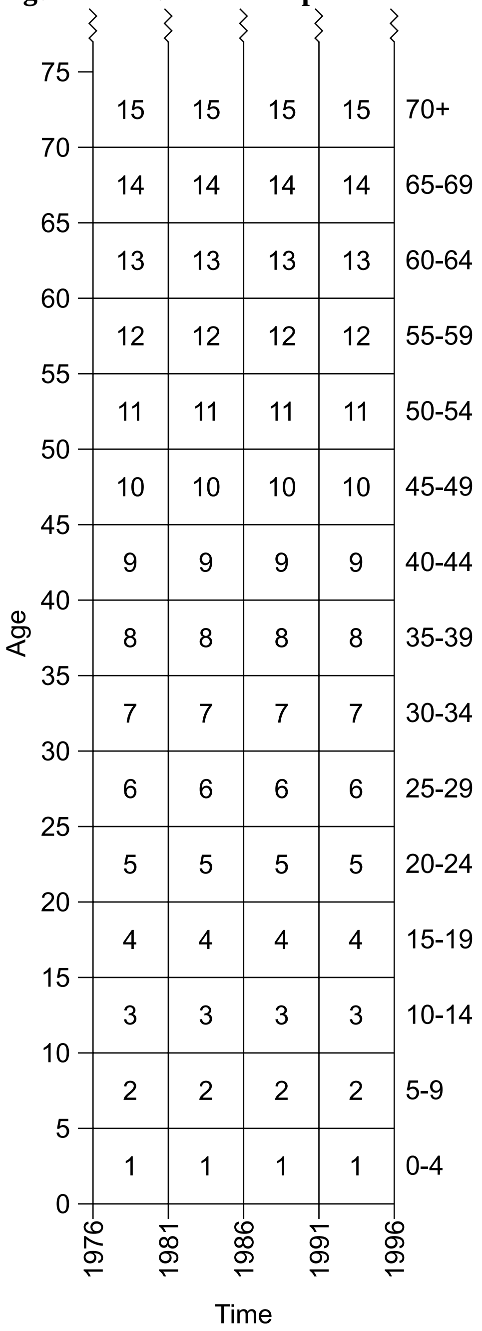


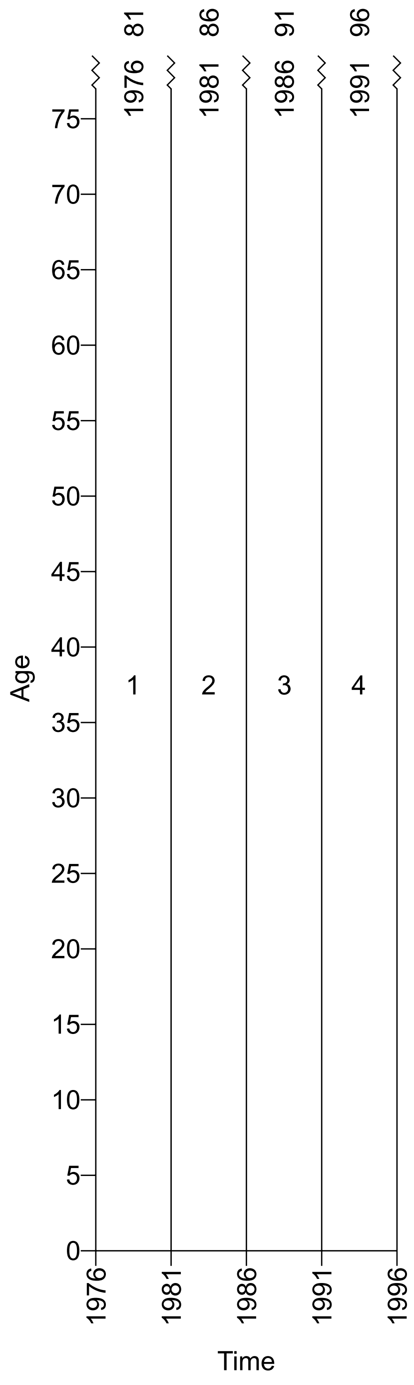
Table 2: Period-cohorts and age-period-cohorts and associated codes

Age at start of interval	Age at end of interval	Period-cohort code
Birth	0-4	1
0-4	5-9	2
5-9	10-14	3
10-14	15-19	4
15-19	20-24	5
20p-24	25-29	6
25-29	30-34	7
30-34	35-39	8
35-39	40-44	9
40-44	45-49	10
45-49	50-54	11
50-54	55-59	12
55-59	60-64	13
60-64	65-69	14
65-69	70-74	15
70+	75+	16

Age at migration	Birth cohort	Age-period-cohort code
0-4	younger	1
0-4	older	2
5-9	younger	3
5-9	older	4
10-14	younger	5
10-14	older	6
15-19	younger	7
15-19	older	8
20-24	younger	9
20-24	older	10
25-29	younger	11
25-29	older	12
30-34	younger	13
30-34	older	14
35-39	younger	15
35-39	older	16
40-44	younger	17
40-44	older	18
45-49	younger	19
45-49	older	20
50-54	younger	21
50-54	older	22
55-59	younger	23
55-59	older	24
60-64	younger	25
60-64	older	26
65-69	younger	27
65-69	older	28
70+	younger	29
70+	older	30

Figure 4 & 5: Codes for period-cohort & age-period-cohort





2. Defining temporally consistent regions, 1976-96

2.1 Temporally consistent regions for Australia

A common problem that confronts time series analysis of Census data is changes 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 a group of LGAs. Substantial changes have been made to SLA boundaries in most states and territories over the past two decades. Derivation of a regional framework for migration analysis over the four intercensal periods 1976-81 to 1991-96 therefore requires identification of regions each comprising one or more whole SLAs with a common outer boundary.

The approach adopted for this project builds on the next level but one of the spatial hierarchy in the Australian Standard Geographic Classification: the Statistical Division (SD). SDs were designed to represent '…large…relatively homogeneous regions characterised by identifiable social and economic links between the inhabitants and between the economic units within the region, under the unifying influence of one or more major towns or cities' (ABS 1991). 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 defined 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 and 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 11 in New South Wales to three in Tasmania.

GIS spatial overlay techniques were used to compare the SD and SLA boundaries at each of the four Censuses from 1981 to 1996. Visual comparisons were then made to identify where boundary changes had occurred and a heuristic procedure was used to search for the nearest set of temporally consistent boundaries at SLA level. Thus, where possible, the original SD boundaries were amended by adding or subtracting adjacent SLAs. A number of principles were adopted to guide this search and adjustment procedure:

- As far as possible the 1996 SD boundaries were adopted as the standard and earlier boundaries were adjusted to match as required. In a number of cases, however, the logistics of boundary selection necessitated adopting an earlier Census as the standard. In Victoria, for example, wholesale changes were made to SD boundaries between 1991 and 1996. Fitting to the 1996 boundaries would have required adjustment to the 1981, 1986 and 1991 boundaries whereas fitting to the 1986 boundaries was considerably less complex.
- Where temporal consistency required realignment of all SD boundaries, the choice of SLAs to include/exclude was made to minimise, as far as possible, aggregate differences in population change.
- In several instances, minor realignments had been made to SD boundaries, which involved comparatively small geographic areas. The size of the population involved in each case was estimated by analysis of Census data for the constituent CDs. Where the population in the realigned area represented less than one per cent of the aggregate population of any of the affected SDs, the temporal inconsistency was accepted.

Together the capital city SDs in the five mainland states account for almost 60 per cent of the total Australian 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 encompass these types of movement each of the five capital city SDs was split into three sub-regions based on the inner, middle and outer suburbs. In each case, these were defined by reference to SLA boundaries and designed to be consistent with the inner/middle/outer suburb definitions adopted by State planning agencies. Special mention should be made of the southeast Queensland region where changes to boundaries around the Brisbane Statistical Division effectively necessitated an alternative approach to boundary definition. Here, the outer boundary of Brisbane City was adopted as an alternative capital city definition and the remaining parts of Brisbane SD combined with Moreton SD and split radially into three sectors.

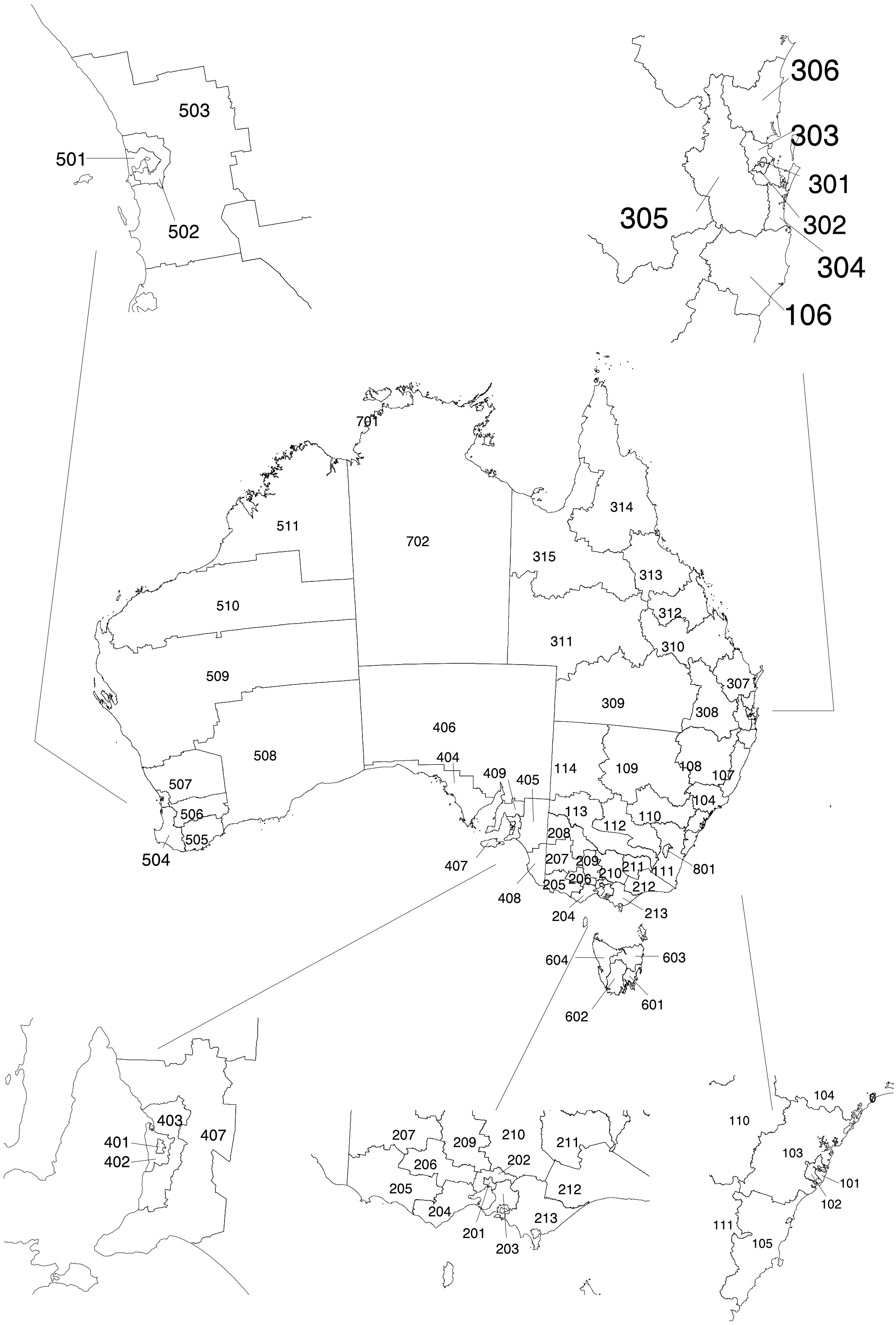
The result of this analysis is a set of 69 regions which are temporally consistent over the 1981, 1986 1991 and 1996 Censuses. For the purposes of brevity, these are defined as TSDs (temporal statistical divisions). The 69 regions are listed below in Table 3 and mapped in Figure 6. Underlying these TSDs are four concordance tables, one for each census year, which list which SLAs are aggregated into which TSDs. The 1996 concordance file was used to build the final TSD boundaries from the 1996 SLA boundaries. The other concordances were used to aggregate the migration data. Full details of the composition of each region at each Census are available by contacting mblake@gisca.adelaide.edu.au

Table 3: Temporal statistical division in Australia

State	TSD	Code	State	TSD	Code
NSW	Inner Sydney	101	Qld	South West	309
NSW	Middle Sydney	102	Qld	Fitzroy	310
NSW	Outer Sydney	103	Qld	Central West	311
NSW	Hunter	104	Qld	Mackay	312
NSW	Illawarra	105	Qld	Northern	313
NSW	Richmond-Tweed	106	Qld	Far North	314
NSW	Mid-North Coast	107	Qld	North West	315
NSW	Northern	108	SA	Inner Adelaide	401
NSW	North Western	109	SA	Middle Adelaide	402
NSW	Central West	110	SA	Outer Adelaide	403
NSW	South Eastern	111	SA	Eyre	404
NSW	Murrumbidgee	112	SA	Murray Lands	405
NSW	Murray	113	SA	Northern	406
NSW	Far West	114	SA	Peri-metro Adelaide	407
Vic	Inner Melbourne	201	SA	South East	408
Vic	Outer Melbourne North	202	SA	Yorke and Lower North	409
Vic	Outer Melbourne South	203	WA	Inner Perth	501
Vic	Barwon	204	WA	Middle Perth	502
Vic	Western Districts	205	WA	Outer Perth	503
Vic	Central Highlands	206	WA	South West	504
Vic	Wimmera	207	WA	Lower Great Southern	505
Vic	Mallee	208	WA	Upper Great Southern	506
Vic	Loddon	209	WA	Midlands	507
Vic	Goulburn	210	WA	South Eastern	508
Vic	Ovens-Murray	211	WA	Central	509
Vic	East Gippsland	212	WA	Pilbara	510
Vic	Gippsland	213	WA	Kimberley	511
Qld	Inner Brisbane	301	Tas	Greater Hobart	601
Qld	Middle Brisbane	302	Tas	Southern	602
Qld	Outer Brisbane	303	Tas	Northern	603
Qld	Gold Coast	304	Tas	Mersey-Lyell	604
Qld	Ipswich	305	NT	Darwin	701
Qld	Caboolture	306	NT	NT Balance	702
Qld	Wide Bay-Burnett	307	ACT	ACT	801
Qld	Darling Downs	308			

Notes: NSW = New South Wales; Vic = Victoria; Qld = Queenslannd; SA= South Australia; WA = Western Australia; Tas = Tasmania; NT = Northern Territory; ACT = Australian Capital Territory.

Figure 6: Temporal statistical divisions in Australia



2.2 Temporally consistent regions for the United Kingdom

Apart from very minor changes the boundaries of the spatial unit used in the NHSCR migration counting system remain constant. 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 force us to carry out 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 within Scotland flows. There is little point in using AHB areas in Scotland given the within-Scotland hole in the migration array for 1983-92 and the Scotland-England and Wales hole for 1976-83. A decision was taken therefore to treat Scotland as one zone in the system. Major investment is required by the NHS and the General Register Office Scotland to improve these statistics.

The second required aggregation concerns FHSAs in London. Before 1983, the West London FHSAs of Barnet, Hillingdon, Brent-Harrow, and Ealing-Hammersmith-Hounslow were combined as 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.

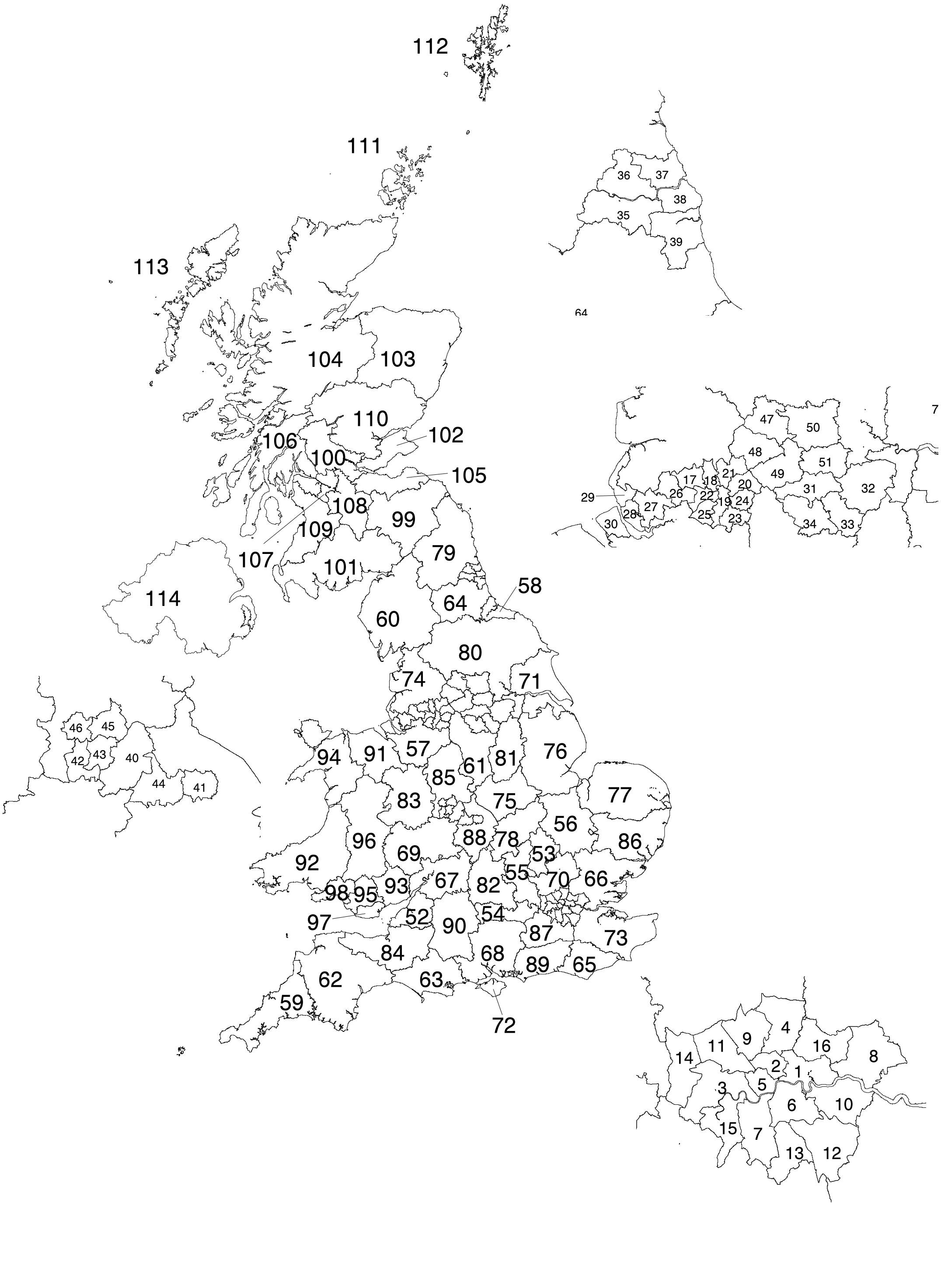
Table 4 sets out areas used in the current age-period-cohort (APC) database, grouping Area Health Boards in Scotland into a single region, Scotland. Figure 7 shows the boundaries of these 96 temporally consistent regions.

Table 4: Areas used in the NHSCR migration statistics and the APC database, Britain

Region	FHSA name	Code	Region	FHSA name	Code
NI	Northern Ireland	1	SE	Hampshire	49
SC	Scotland	2	SE	Isle Of Wight	50
NO	Gateshead	3	SE	Kent	51
NO	Newcastle	4	SE	Oxfordshire	52
NO	North Tyneside	5	SE	Surrey	53
NO	South Tyneside	6	SE	West Sussex	54
NO	Sunderland	7	SW	Avon	55
NO	Cleveland	8	SW	Cornwall	56
NO	Cumbria	9	SW	Devon	57
NO	Durham	10	SW	Dorset	58
NO	Northumberland	11	SW	Gloucestershire	59
YH	Barnsley	12	SW	Somerset	60
YH	Doncaster	13	SW	Wiltshire	61
YH	Rotherham	14	WM	Birmingham	62
YH	Sheffield	15	WM	Coventry	63
YH	Bradford	16	WM	Dudley	64
YH	Calderdale	17	WM	Sandwell	65
YH	Kirklees	18	WM	Solihull	66
YH	Leeds	19	WM	Walsall	67
YH	Wakefield	20	WM	Wolverhampton	68
YH	Humberside	21	WM	Hereford and Worcester	69
YH	North Yorkshire	22	WM	Shropshire	70
EM	Derbyshire	23	WM	Staffordshire	71
EM	Leicestershire	24	WM	Warwickshire	72
EM	Lincolnshire	25	NW	Bolton	73
EM	Northamptonshire	26	NW	Bury	74
EM	Nottinghamshire	27	NW	Manchester	75
EA	Cambridgeshire	28	NW	Oldham	76
EA	Norfolk	29	NW	Rochdale	77
EA	Suffolk	30	NW	Salford	78
GL	City, Hackney, Newham and Tower Hamlets	31	NW	Stockport	79
GL	Redbridge and Waltham Forest	32	NW	Tameside	80
GL	Barking and Havering	33	NW	Trafford	81
GL	Camden and Islington	34	NW	Wigan	82
GL	Kensington & Chelsea and Westminster	35	NW	Liverpool	83
GL	Richmond and Kingston	36	NW	St.Helens and Knowsley	84
GL	Merton & Sutton and Wandsworth	37	NW	Sefton	85
GL	Croydon	38	NW	Wirral	86
GL	Lambeth, Southwark and Lewishm	39	NW	Cheshire	87
GL	Bromley	40	NW	Lancashire	88
GL	Bexley and Greenwich	41	WA	Clwyd	89
GL	Middlesex	42	WA	Dyfed	90
SE	Bedfordshire	43	WA	Gwent	91
SE	Buckinghamshire	44	WA	Gwynedd	92
SE	Essex	45	WA	Mid Glamorgan	93
SE	Hertfordshire	46	WA	Powys	94
SE	Berkshire	47	WA	South Glamorgan	95
SE	East Sussex	48	WA	West Glamorgan	96

Notes: Regions: NI = Northern Ireland, SC = Scotland, NO = North, YH = Yorkshire and Humberside, EM = East Midlands, EA = East Anglia, GL = Greater London, SE = South East (rest), SW = South West, WM = West Midlands, NW = North West, WA = Wales

Figure 7: FHSA areas in Britain



3. A reduced region set

3.1 A reduced region set for Australia

While the TSDs provide a detailed regional breakdown of Australia, a 69 by 69 flow matrix is too large for convenient visualisation and analysis. For the purposes of the APC analysis, a set of aggregated regions was therefore derived by amalgamating regions with similar functional characteristics. This aggregation was based on previous analyses of inter-regional migration flows and networks undertaken by Maher and Bell (1995) which sought to classify regions according to the composition of their inwards and outwards migration flows, and the roles and functions they performed within the settlement system. That analysis identified six principal types of regions: the major metropolitan areas (Sydney and Melbourne), the minor metropolitan centres (Adelaide, Perth, Brisbane and Hobart), specialised economic regions (Canberra, Darwin and the mining regions of the interior), adjacent near city regions, the amenity-rich coast, and the balance of non-metropolitan Australia (principally the wheat-sheep belt and interior).

The reduced region set utilises this classification as an organising framework in combination with a city region system based around the 8 state and territory capitals and their respective hinterlands. The resulting regional classification, consisting of 38 Australian city regions, also termed ATSDs (aggregate temporal statistical divisions), is defined in Table 5, which is a look-up table that shows the composition of each Australian city region in terms of its member TSDs. Figure 8 maps the boundaries of the Australian city regions and also provides a 1991 population based cartogram of the regions, developed using the Dorling (1996) algorithm

3.2 A reduced region set for Britain

The regional aggregations have been carried out on a uniform set of files for 96 areas in form of ODAS arrays from 1976-77 to 1995-96. Table 6 shows the make-up of the British city regions interms of temporary consistent FHSAs. The equivalent look-up table that shows the aggregation from FHSAs to British city regions is given in Appendix 2. Figure 9 maps the British city regions 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. Regions have Cores (the largest metropolitan district usually or county match), Rest of Metro County, Near Non-metro Counties or Far Non-metro Counties. The classification can be collapsed to city regions or to cores, rest, near, far or to metro-non-metro or to north-south divisions. The classification is based principally on contiquity and knowledge of migration flows, but not on any formal analysis.

Table 5: Composition of Australian city regions in terms of TSDs

State	Code	TSD_Code	TSD	ATSD Code	ATSD
NSW	1	101	Inner Sydney	1	Sydney Core
NSW	2	102	Middle Sydney	1	Sydney Core
NSW	3	103	Outer Sydney	2	Sydney Rest
NSW	4	104	Hunter	3	Sydney Near Hunter
NSW	5	105	Illawarra	4	Sydney Near Illawarra
NSW	6	106	Richmond-Tweed	5	Sydney Coast North
NSW	7	107	Mid-North Coast	5	Sydney Coast North
NSW	8	108	Northern	6	Sydney Far
NSW	9	109	North Western	7	Sydney Remote
NSW	10	110	Central West	6	Sydney Far
NSW	11	111	South Eastern	8	Sydney Coast South
NSW	12	112	Murrumbidgee	6	Sydney Far
NSW	13	113	Murray	6	Sydney Far
NSW	14	114	Far West	7	Sydney Remote
Vic	15	201	Inner Melbourneourne	9	Melbourne Core
Vic	16	202	Outer Melbourneourne Nth	10	Melbourne Rest
Vic	17	203	Outer Melbourneourne Sth	10	Melbourne Rest
Vic	18	204	Barwon	11	Melbourne Near
Vic	19	205	Western Districts	12	Melbourne Far West
Vic	20	206	Central Highlands	11	Melbourne Near
Vic	21	207	Wimmera	12	Melbourne Far West
Vic	22	208	Mallee	12	Melbourne Far West
Vic	23	209	Loddon	11	Melbourne Near
Vic	24	210	Goulburn	11	Melbourne Near
Vic	25	211	Ovens-Murray	13	Melbourne Far East
Vic	26	212	East Gippsland	13	Melbourne Far East
Vic	27	213	Gippsland	13	Melbourne Far East
Qld	28	301	Inner Brisbane	14	Brisbane Core
Qld	29	302	Middle Brisbane	14	Brisbane Core
Qld	30	303	Outer Brisbane	15	Brisbane Rest
Qld	31	304	Gold Coast	17	Brisbane Coast Gold Coast
Qld	32	305	Ipswich	16	Brisbane Near
Qld	33	306	Caboolture	18	Brisbane Coast Sunshine Coast
Qld	34	307	Wide Bay-Burnett	18	Brisbane Coast Sunshine Coast
Qld	35	308	Darling Downs	19	Brisbane Far
Qld	36	309	South West	22	Brisbane Remote
Qld	37	310	Fitzroy	20	Brisbane Coast Centre
Qld	38	311	Central West	22	Brisbane Remote
Qld	39	312	Mackay	20	Brisbane Coast Centre
Qld	40	313	Northern	21	Brisbane Coast North
Qld	41	314	Far North	21	Brisbane Coast North
Qld	42	315	North West	22	Brisbane Remote
SA	43	401	Inner Adelaide	23	Adelaide Core
SA	44	402	Middle Adelaide	23	Adelaide Core
SA	45	403	Outer Adelaide	24	Adelaide Rest
SA	46	404	Eyre	26	Adelaide Far
SA	47	405	Murray Lands	26	Adelaide Far
SA	48	406	Northern	27	Adelaide Remote
SA	49	407	Peri-metro Adelaideaide	25	Adelaide Near
SA	50	408	South East	26	Adelaide Far
SA	51	409	Yorke and Lower North	25	Adelaide Near
WA	52	501	Inner Perth	28	Perth Core
WA	53	502	Middle Perth	28	Perth Core
WA	54	503	Outer Perth	29	Perth Rest
WA	55	504	South West	30	Perth Near
WA	56	505	Lower Great Southern	31	Perth Far
WA	57	506	Upper Great Southern	31	Perth Far
WA	58	507	Midlands	30	Perth Near
WA	59	508	South Eastern	32	Perth Remote
WA	60	509	Central	32	Perth Remote
WA	61	510	Pilbara	32	Perth Remote
WA	62	511	Kimberley	32	Perth Remote
Tas	63	601	Greater Hobart	33	Hobart Core
Tas	64	602	Southern	34	Hobart Near
Tas	65	603	Northern	34	Hobart Near
Tas	66	604	Mersey-Lyell	35	Hobart Far
NT	67	701	Darwin	36	Darwin Core
NT	68	702	NT Balance	37	Darwin Remote
ACT	69	801	ACT	38	ACT

Figure 8: Australian city regions

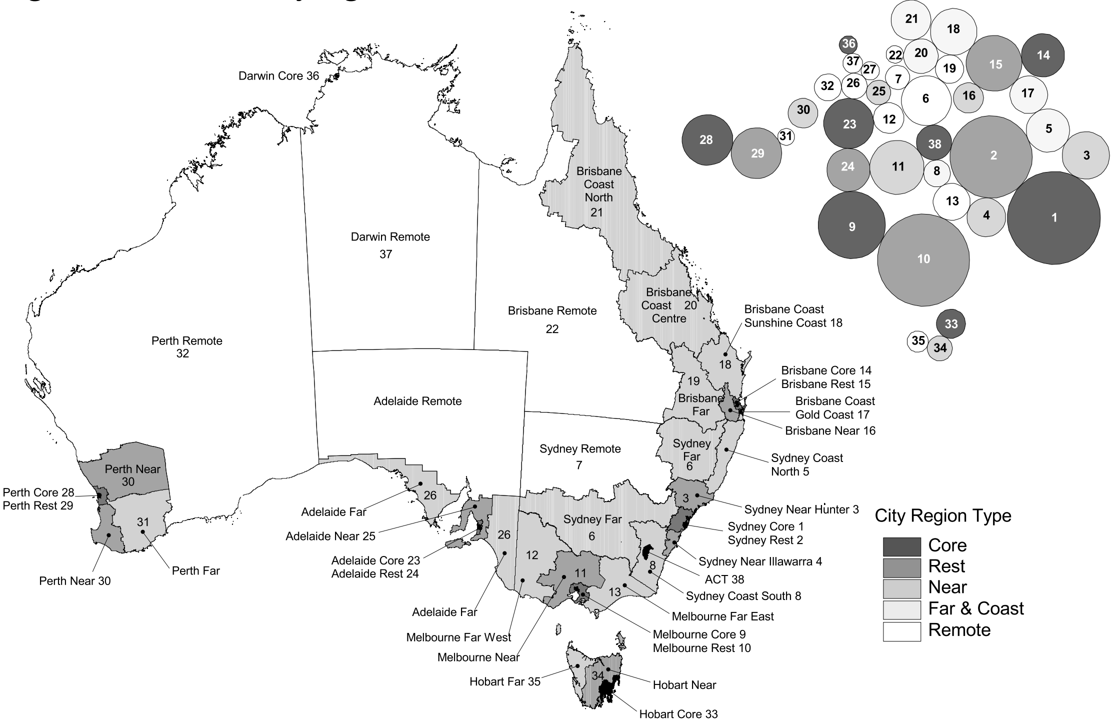
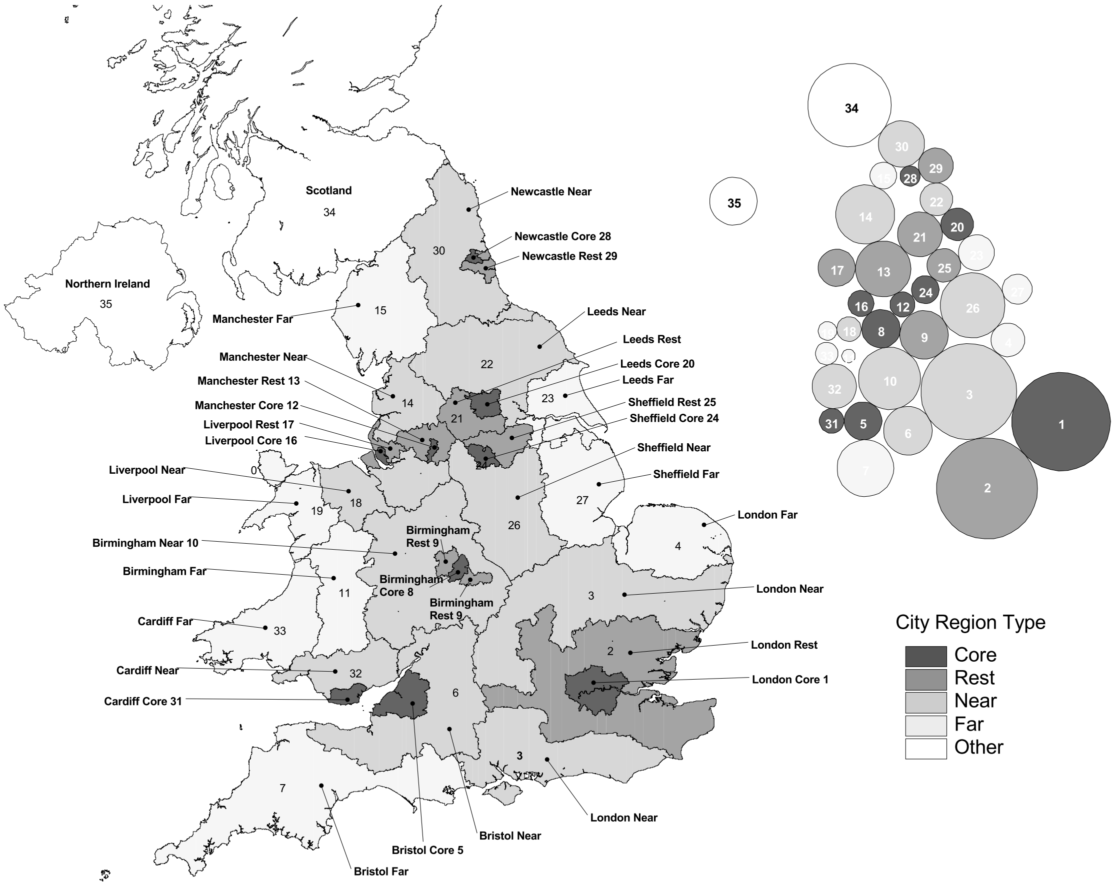


Table 6: Composition of the British city regions in terms of FHSAs, Britain

No.	New "city" regions	FHSA areas making up new "city" regions
1	London Core	City of London, Hackney, Newham, and Tower Hamlets, Redbridge, Waltham Forest, Barking, Havering, Camden, Islington, Kensington & Chelsea, Westminster, Richmond, Kingston, Merton, Sutton, Wandsworth, Croydon, Lambeth, Southwark, Lewisham, Bromley, Bexley, Greenwich, Middlesex
2	London Rest	Buckinghamshire, Essex, Hertfordshire, Berkshire, Kent, Surrey
3	London Near	Bedfordshire, Cambridgeshire, East Sussex, Hampshire, Isle of Wight, Northamptonshire, Oxfordshire, Suffolk, West Sussex
4	London Far	Norfolk
5	Bristol Core	Avon
6	Bristol Near	Gloucestershire, Somerset, Wiltshire
7	Bristol Far	Cornwall, Devon, Dorset
8	Birmingham Core	Birmingham
9	Birmingham Rest	Coventry, Dudley, Sandwell, Solihull, Walsall, Wolverhampton
10	Birmingham Near	Hereford and Worcester, Shropshire, Staffordshire, Warwickshire
11	Birmingham Far	Powys
12	Manchester Core	Manchester
13	Manchester Rest	Bolton, Bury, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford, Wigan
14	Manchester Near	Cheshire, Lancashire
15	Manchester Far	Cumbria
16	Liverpool Core	Liverpool
17	Liverpool Rest	St. Helens & Knowsley, Sefton, Wirral
18	Liverpool Near	Clwyd
19	Liverpool Far	Gwynedd
20	Leeds Core	Leeds
21	Leeds Rest	Bradford, Calderdale, Kirklees, Wakefield
22	Leeds Near	North Yorkshire
23	Leeds Far	Humberside
24	Sheffield Core	Sheffield
25	Sheffield Rest	Barnsley, Doncaster, Rotherham
26	Sheffield Near	Derbyshire, Leicestershire, Nottinghamshire
27	Sheffield Far	Lincolnshire
28	Newcastle Core	Newcastle
29	Newcastle Rest	Gateshead, North Tyneside, South Tyneside, Sunderland
30	Newcastle Near	Cleveland, Durham, Northumberland
31	Cardiff Core	South Glamorgan
32	Cardiff Near	Gwent, Mid Glamorgan, West Glamorgan
33	Cardiff Far	Dyfed
34	Scotland	Scotland
35	Northern Ireland	Northern Ireland

Figure 9: British city regions



4. Acquisition and processing of migration flow matrices

4.1 Acquisition and preliminary processing of migration flow matrices in Australia

Four origin-destination matrices were acquired from ABS containing migration flows between the 69 TSDs over the intercensal periods 1976-81, 1981-86, 1986-91 and 1991-96. Each table 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 matrices came in two formats. A binary format which could only be read by the Supertable software (files with the extension SRD), and an ASCII format that could be read by purpose written software.

The data were originally acquired as binary Supertable files. While Supertable provides an easy-to-use and quick method of manipulating flow matrices, but it employs textual codes that require conversion to numeric format and exporting to csv files prior to further processing. This is a time-consuming process. The ABS also provided their data as ASCII files, which each flow represented as a separate record, and which uses numeric codes to represent each of the associated variables. These files have the extension MDL. While the data in Supertable files can only be manipulated in Supertable, MDL files can easily manipulated using purpose written software and in the end this proved to be the most flexible option.

Preliminary data processing was undertaken in a single stage using a Visual Basic program and the ABS MDL files. The aim was to restrict processing to a single program so that if, at any time in the future, the database needed to be recreated only a single set of source files and a single program were required. Table 7 lists the source file names

Table 7: Preliminary data processing, input and output file names, Australia

Census Period	Input File Name	Output File Name
1976-81	Sax0237c.mdl	Odas7681-oz.csv
1981-86	Sax0238c.mdl	Odas8186-oz.csv
1986-91	sax0239c.mdl	Odas8691-oz.csv
1991-96	sax0240c.mdl	Odas9196-oz.csv

An MDL file is a plain ASCII file composed of a sequence of records. Each record consists of a comma delimited set of numbers which represent both a set of codes and a number of persons (see listing below). The value of the Persons field represents the number of people (usually enumerated persons) that are defined by the preceding list of variable codes. For example 1030 enumerated male 15-19 year olds moved from TSD code 1 to TSD code 2.

Listing of the first 5 lines of the 1996 MDL file

```
PC96_SEX,PC96_AGEP_AGE,PC96_5_YR_MOBILITY_IND,PC96_SD_UR_5YRS_AGO,PC96_SD_UR_CENSUS_NI
GHT,PERSONS
1,4,2,1,2,1030
1,4,2,1,3,451
1,4,2,1,4,41
1,4,2,1,5,59
```

4.2 Filling in the full migration array, Britain

4.2.1 NHSCR migration data: general attributes

The migration statistics from the NHSCR (Duke-Williams and Stillwell 1999) have been assembled in a general purpose database/extraction system called TIMMIG or Time Series of Migration Data. The original version of this system is described in Rees and Duke-Williams (1993) and has been upgraded with the addition of migration from Quarter 3, 1992 to Quarter 2, 1998, to form a sequence that runs from mid-year 1975 to mid-year 1998 (23 years). Jobs have been run to extract files of migration statistics from the TIMMIG for mid-year to mid-year periods from June 30/July 1 1976 to June 30/July 1 1996.

4.2.2 The processing of full origin-destination-age-sex arrays for 1983 to 1996

The files for years 1983 to 1996 are full origin-destination-age-sex arrays. The origins and destinations are the set of FHSAs in England and Wales and Area Health Boards in Scotland specified in column 4 of Appendix 3 together with Northern Ireland as a single zone. The following files contain these data:

odas8384.csv, odas8485.csv, odas8586.csv, odas8687.csv, odas8788.csv, odas8889.csv, odas8990.csv, odas9091.csv, odas9192.csv, odas9293.csv, odas9394.csv, odas9495.csv, odas9596.csv.

All of these files are located on the machine wallace.leeds.ac.uk in the directory:

```
/data/wallace_1/migdata
```

This directory is accessible to anybody with an account on wallace.leeds.ac.uk. Note that the directory is automounted. Attempting to list the directory /data may show no entries, depending on the current state of the machine. However, attempting to list /data/wallace_1 or any sub-directory of this will cause the disk to be mounted and the correct file list to be displayed.

Two regional aggregations were carried out on these files. The first was to aggregate FHSAs in Middlesex to form one zone and to aggregate the Scottish AHBs to one Scotland zone in order to derive temporally consistent migration statistics (see section 2.2). The aggregations were performed manually after converting the files to EXCEL spreadsheets. The resulting data was saved as a series of files in ‘comma separated values’ format.

To carry out aggregation from this revised set of FHSAs to the 35 new “city regions” (see section 3.2) a Visual Basic program call LuT.bas was used. The outputs of this program were:

ODAS8384_CR.csv, ODAS8485_CR.csv, ODAS8586_CR.csv, ODAS8687_CR.csv, ODAS8788_CR.csv, ODAS8889_CR.csv, ODAS8990_CR.csv, ODAS9091_CR.csv, ODAS9192_CR.csv, ODAS9293_CR.csv, ODAS9394_CR.csv, ODAS9495_CR.csv, ODAS9596_CR.csv

These files are all located on wallace.leeds.ac.uk, in the directory:

```
/data/wallace_3/apcdata
```

The source code for LuT is in the directory:

```
/data/wallace_1/migdata/programs/LuT
```

The files are disaggregated by single years of age and sex, and consequently contain a large number of fields on each line. Some software had difficulty in reading these files, and therefore a complmentary set of files was created in which the data were arranged in a stream, with one field per line. These files are in the same directory, and are named:

ODAS8384_CR.strm, ODAS8485_CR.strm, ODAS8586_CR.strm, ODAS8687_CR.strm, ODAS8788_CR.strm, ODAS8889_CR.strm, ODAS8990_CR.strm, ODAS9091_CR.strm, ODAS9192_CR.strm, ODAS9293_CR.strm, ODAS9394_CR.strm, ODAS9495_CR.strm, ODAS9596_CR.strm

Concern over the accuracy of these files led to equivalent files being produced for the 35 zone geography directly from TIMMIG. The files as produced by TIMMIG are named:

odas8384cr.csv, odas8485cr.csv, odas8586cr.csv, odas8687cr.csv, odas8788cr.csv, odas8889cr.csv, odas8990cr.csv, odas9091cr.csv, odas9192cr.csv, odas9293cr.csv, odas9394cr.csv, odas9495cr.csv, odas9596cr.csv

Again, these were converted to stream files, named:

odas8384cr.strm, odas8485cr.strm, odas8586cr.strm, odas8687cr.strm, odas8788cr.strm, odas8889cr.strm, odas8990cr.strm, odas9091cr.strm, odas9192cr.strm, odas9293cr.strm, odas9394cr.strm, odas9495cr.strm, odas9596cr.strm

All these files are locate in the directory:

```
/data/wallace_3/apcdata
```

Some files are compressed using gzip. gzip is already installed on wallace (and most Unix machines); executable versions for DOS and Mac computers can be obtained from many places, including:

http://crusty.er.usgs.gov/gzip.html

These files are then input to the age-period-cohort processing described below in section 5.2.

4.2.3 The processing of origin-destination, origin-age-sex and destination age-sex arrays for 1976 to 1983

Full arrays are not available for the 1976 to 1983 period. OPCS published instead separate origin-destination (OD), origin-age-sex (OAS) and destination (DAS) arrays. To create a uniform dataset through the study period, it was decided to model the contents of the full ODAS array from these tight constraints using a well-used technique called iterative proportional fitting. The framework and techniques for filling in such arrays were developed by Willekens in the 1970s (see Rees and Willekens 1986 for an account). Although these techniques do not recover the original ODAS flows with full accuracy, use of the OD, OAS and DAS arrays aggregated to 35 regions and the later aggregation of the rersults to five year time periods will yield estimates pretty close to the observed flows

A brief account of the iterative proportional fitting routine used is given here. Its purpose is to estimate the full migration array for each period from the partial information provided. The following notation is adopted.

The target variable to be estimated is as follows:

M(i,j,a,s) = migrations from origin i to destination j, by persons in age a and sex s.

The period subscript is not used because the method applies to each period separately.

The information that is known is:
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 origin j in age group a = $_{i}$ M(i,j,a,s)

[1] = the step number in the algorithm

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 intial values

For all i, j and a

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

This initial assignment was preferred to using the M(i,j,a,s) values for the first period for which the full array was available, because each i, j, a, s flow has a chance of representation. If an actual array had been chosen as the starting value, flows which were zero in that year, would never have a chance of being estimated.

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)[3] - M(i,j,a,s) [1]}

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

The stopping criterion is set at half a migration.

The input files to this estimation process are as follows:

oas7677.csv, oas7778.csv, osa7879.csv, oas7980.csv, oas8081.csv, oas8182.csv, oas8283.csv
das7677.csv, das7778.csv, osa7879.csv, das7980.csv, das8081.csv, das8182.csv, das8283.csv
od7677.csv, od7778.csv, osa7879.csv, od7980.csv, od8081.csv, od8182.csv, od8283.csv

These files are all located on wallace.leeds.ac.uk in the directory:

```
/data/wallace_1/migdata
```

As with the previously mentioned files, they may be compressed using gzip.

The files were processed using a Visual Basic program called ipf, the source code and supporting files for which are in the directory:

```
/data/wallace_1/migdata/programs/ipf
```

The output files from this process are as follows:

IPF_ODAS7677.csv, IPF_ODAS7778.csv, IPF_ODAS7879.csv, IPF_ODAS7980.csv, IPF_ODAS8081.csv, IPF_ODAS8182.csv, IPF_ODAS8283.csv

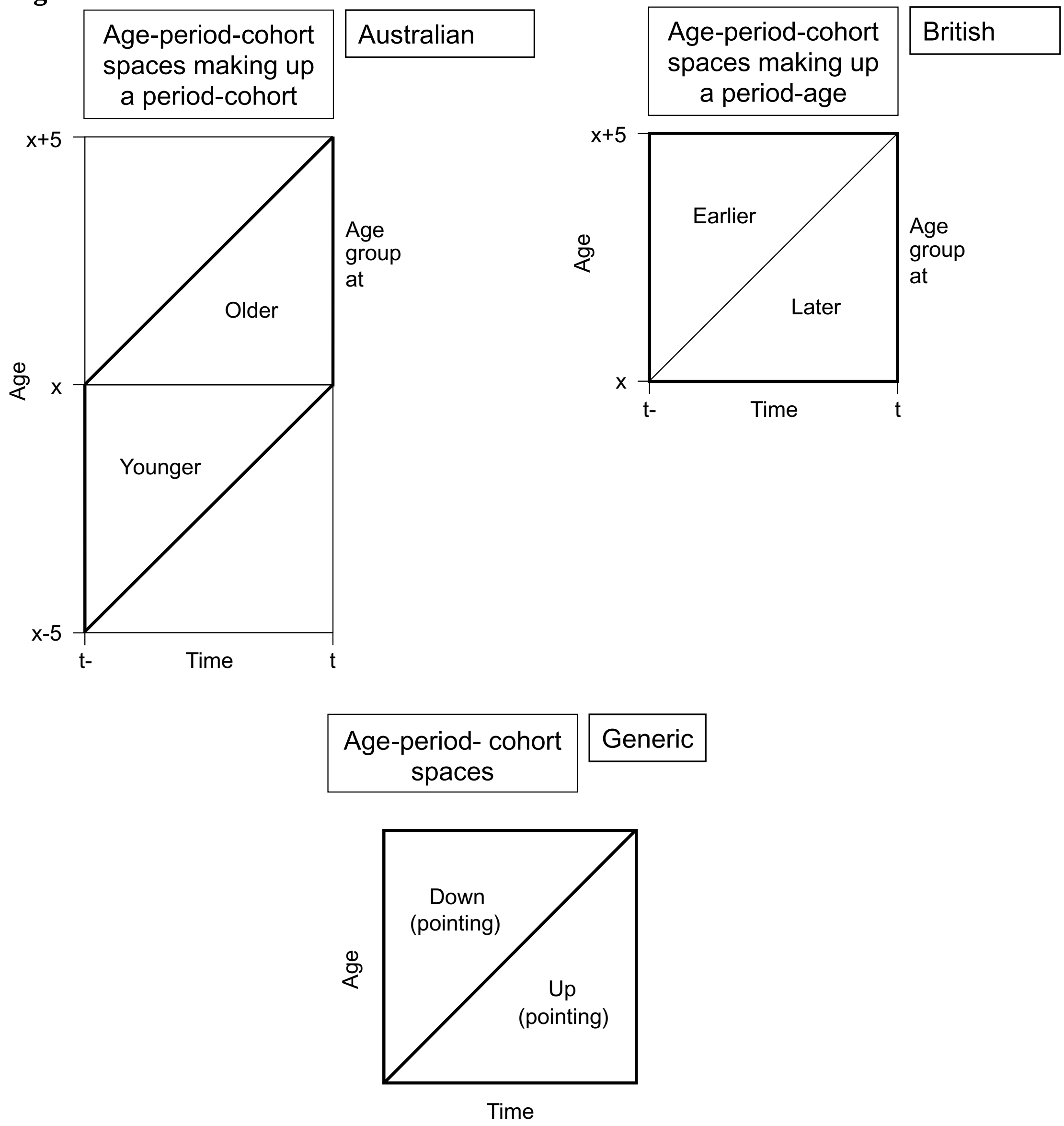
These files are located on wallace.leeds.ac.uk in the directory /data/wallace_3/apcdata and are used in the age-period-cohort processing (see section 5.2).

5. Processing into age-period-cohort flows

In this section of the paper we describe the final stage of processing necessary to create comparable age-period-cohort migration time series for the periods 1976-81, 1981-86, 1986-91 and 1991-96 in Australia and Britain. The target aim is that all migration flows are classified by age, period and cohort simultaneously, so that when migration measures are computed they can be done so for comparable APC spaces.. Figure 10 shows a series of age-period-cohort diagrams that illustrate what is involved. The top diagram, which applies to the Australian data, shows how a period-cohort space is made up of two age-period-cohort spaces (triangles) aligned 'on top' of each other. The middle diagram, which applies to the British data, shows how the period-age space is also composed of two age-period-cohort spaces (triangles), aligned next to each other. In the first case, age-period-cohort spaces are naturally labeled "younger" and "older". In the second diagram, the age-period-cohort spaces are naturally labeled "earlier" and "later". Because we use both views of the data confusion can develop. A more generic terminology is described in the third diagram which defines the two age-period-cohort spaces as "down" and "up", which are 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.

Creating the Australian database requires that the period-cohorts, in which Australian census data is naturally reported, are decomposed into the older age (up) and younger age (down) APC spaces which make up the period-cohort space. This split is based on a series of separation factors derived from national mobility profiles for the start and end of each intercensal period, classified by sex and single years of age, derived from the Census one year mobility question. 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. For the 1976-81 period, we only have five of age information and rather simple assumptions are made about the distribution of migration in age-time space. For 1983 to 1996, migration statistics are available for single years of age and time, and simple aggregation to five year age-time spaces can be used for most of the task, confining assumptions to a subset of one year period-ages.

Figure 10: Frameworks for age-period-cohort processing of Australian and British migration data



5.1 Disaggregation into age-period-cohort flows: Australian migration data

5.1.1 Computation of separation factors

Census data based on current and previous place of usual residence measure migration as a single transition over a fixed interval. Age is measured at the end of the intercensal period rather than at the time migration occurred. The observation plan for the data is therefore of the period-cohort type and the age designated in cross-classified tables is more accurately defined by reference to year of birth (Figure 11). Thus, internal migrants aged 15-19 in 1996 were aged 10-14 in 1991 (at the start of the 1991-96 migration interval) and were born between 1976 and 1981. Conversely, from a cohort perspective, the 1976-81 birth cohort were aged 0-4 in 1981 and 5-9 in 1986. Juxtaposing adjacent migration intervals thus provides the basis on which to trace the migration history of selected birth cohorts. In each case, however, the movement data for a given cohort in a given year (period) as reported in the Census, refer to the ‘diamond’ shaped area with lines at 45 degrees delimiting its vertical extent. For the purposes of APC analysis, it is necessary to disaggregate the movements of each of these period-cohort flows based on the age at which migration occurred (effectively segmenting the period-cohort space into its two constituent age-period-cohort spaces - the triangles divided by the horizontal line). Thus, movements of the 1976-81 birth cohort in the 1991-96 intercensal period must be segmented into those that occurred at ages 10-14 and those that occurred at ages 15-19.

These data are not directly available from the Census and must be estimated. 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 1971-76 birth cohort during the 1991-96 intercensal period. This group were aged 15-19 in 1991 and 20-24 in 1996, but the bulk of the movement almost certainly occurred among the older members of this cohort: that is in the upper triangle of the period-cohort diamond.

For the purposes of this project, the period-cohort data for each inter-regional flow were split into age components based on separation factors derived from national mobility profiles for single year intervals by sex and single years of age. Profiles of movement between statistical divisions (as defined at each Census) were acquired from ABS for the single year intervals 1975-76, 1980-81, 1985-86 and 1995-96, disaggregated by sex and single years of age. These were converted to conditional migration probabilities [movers/(movers+non-movers)] by sex and single years of age. Probabilities for intermediate years were then derived by linear interpolation. This procedure delivers a matrix of migration probabilities by single years of age from 1 to 99 and over (age measured at the end of the interval) at single year intervals from 1975-76 to 1995-96, for each sex.

Separation factors for each period-cohort in each interval were then derived by summing the appropriate propensities in each age-period-cohort 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 segments were split between segments as weighted averages of the probabilities in the adjacent period-cohorts (Figure 12).

Figure 11: Lexis diagram illustrating age-time observation plans

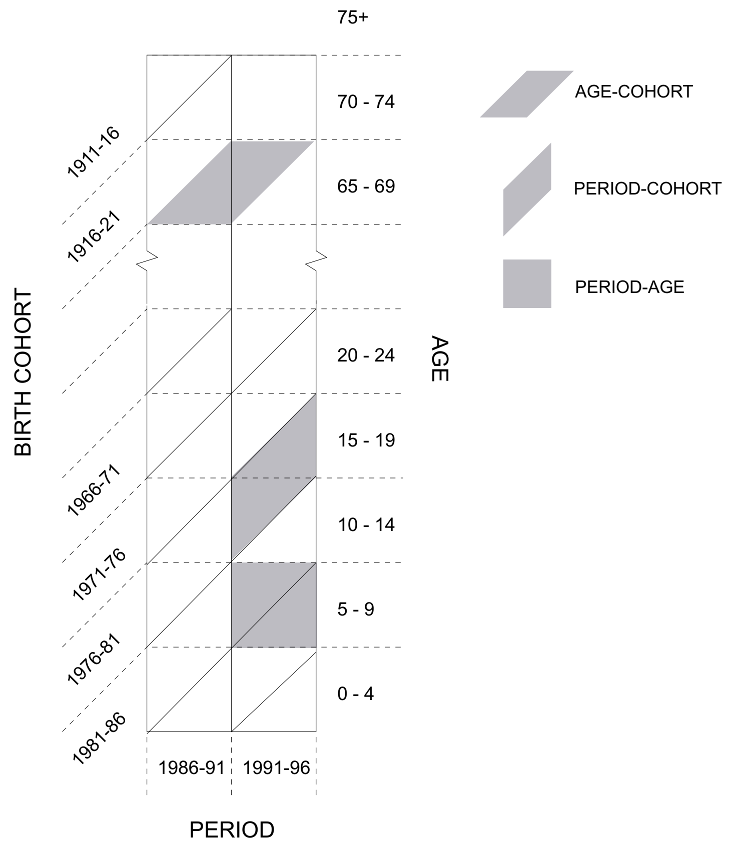
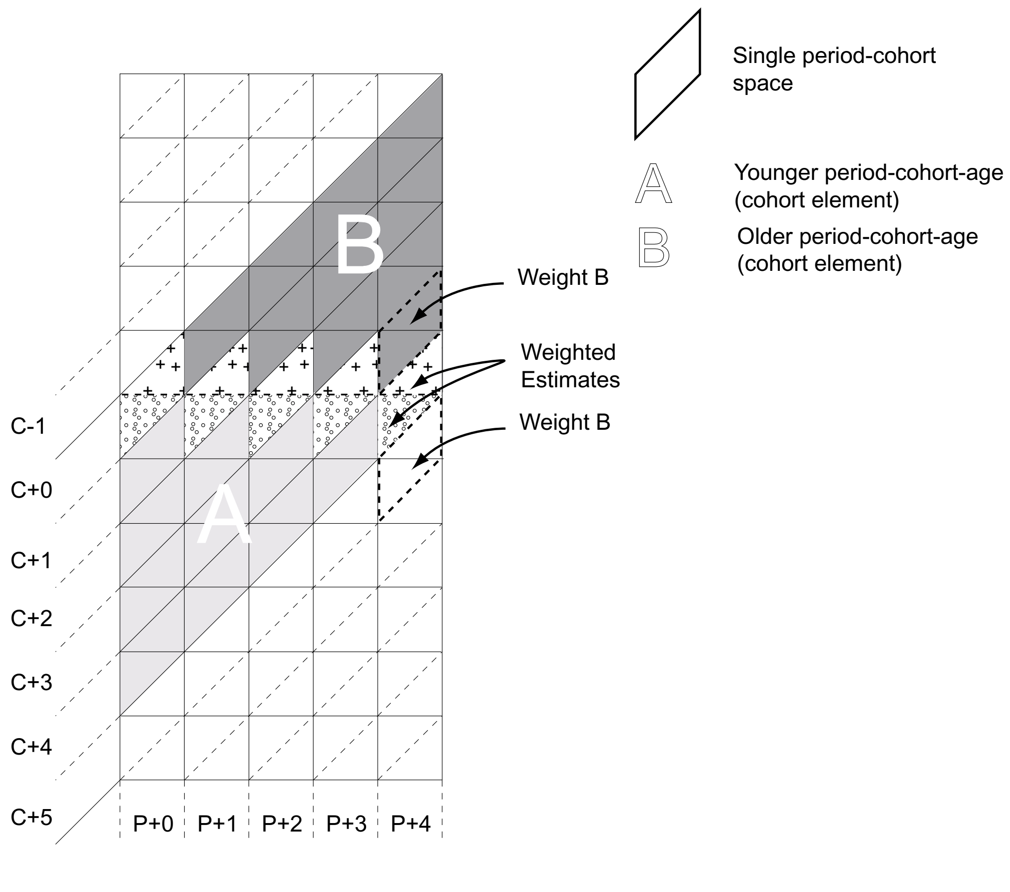


Figure 12: Calculation of separation factors to split period cohort flows between older and younger period-cohort spaces, Australia



Formally:

Let R_{sPC} be a matrix of inter-regional migration probabilities disaggregated by sex (s), single year intervals (P) and single year of birth cohorts (C)

Let S_{spca} be a matrix of separation factors for a five year interval (p) disaggregated by sex (s), five year birth cohorts (c) and five year age groups (a)

Further, to simplify the notation,

index p by reference to the earliest year in the five year interval and define P=p
index c by reference to the earliest year of the birth cohort and define C=c
index a by reference to the youngest age of the five year age group and define a=p-c

Then:

S_{spca-5} = A/{A+B} and
S_{spca} = B/{A+B} = 1-S_{spca-5}

For "0-4 to 5-9" ≤ period-cohort ≤ "65-69 to 70-74"

A = $R_{s,P,C+1}$ +
$R_{s,P,C+2}$ + $R_{s,P+1,C+2}$+
$R_{s,P,C+3}$ + $R_{s,P+1,C+3}$ + $R_{s,P+2,C+3}$+
$R_{s,P,C+4}$ + $R_{s,P+1,C+4}$ + $R_{s,P+2,C+4}$+ $R_{s,P+3,C+4}$+
$R_{s,P,C}$ * $R_{s,P,C+1}$ / [$R_{s,P,C+1}$+ $R_{s,P,C-1}$] +
$R_{s,P+1,C+1}$ * $R_{s,P+1,C+2}$ / [$R_{s,P+1,C+2}$+ $R_{s,P+1,C}$] +
$R_{s,P+2,C+2}$ * $R_{s,P+2,C+3}$ / [$R_{s,P+2,C+3}$+ $R_{s,P+2,C+1}$] +
$R_{s,P+3,C+3}$ * $R_{s,P+3,C+4}$ / [$R_{s,P+3,C+4}$+ $R_{s,P+3,C+2}$] +
$R_{s,P+4,C+4}$ * $R_{s,P+4,C+5}$ / [$R_{s,P+4,C+5}$+ $R_{s,P+4,C+3}$]

and

B = $R_{s,P+4,C+3}$ +
$R_{s,P+3,C+2}$ + $R_{s,P+4,C+2}$+
$R_{s,P+2,C+1}$ + $R_{s,P+3,C+1}$ + $R_{s,P+4,C+1}$+
$R_{s,P+1,C}$ + $R_{s,P+2,C}$ + $R_{s,P+3,C}$+ $R_{s,P+4,C}$+
$R_{s,P,C}$ * $R_{s,P,C-1}$ / [$R_{s,P,C+1}$+ $R_{s,P,C-1}$] +
$R_{s,P+1,C+1}$ * $R_{s,P+1,C}$ / [$R_{s,P+1,C+2}$+ $R_{s,P+1,C}$] +
$R_{s,P+2,C+2}$ * $R_{s,P+2,C+1}$ / [$R_{s,P+2,C+3}$+ $R_{s,P+2,C+1}$] +
$R_{s,P+3,C+3}$ * $R_{s,P+3,C+2}$ / [$R_{s,P+3,C+4}$+ $R_{s,P+3,C+2}$] +
$R_{s,P+4,C+4}$ * $R_{s,P+4,C+3}$ / [$R_{s,P+4,C+5}$+ $R_{s,P+4,C+3}$]

These may be more economically written as:

$$A = \sum_{x=0}^{x=3}\sum_{y=x+1}^{y=4} R_{p+x,c+y} + \sum_{x=0}^{x=4} R_{p+x,c+x}\left[\frac{R_{p+x,c+x+1}}{R_{p+x,c+x+1} + R_{p+x,c+x-1}}\right]$$

and

$$B = \sum_{x=1}^{x=4}\sum_{y=0}^{y=x-1} R_{p+x,c+y} + \sum_{x=0}^{x=4} R_{p+x,c+x}\left[\frac{R_{p+x,c+x-1}}{R_{p+x,c+1} + R_{p+x,c+x-1}}\right]$$

for period-cohort = "70+ to 75+"

Special procedures are needed for the oldest period-cohort since this group is open ended. In this case summing rates would give markedly differing results depending on the final age for which data are available. The factors are therefore computed using raw data on migrations (transitions). Thus, let T_{sPC} be a matrix of inter-regional migration probabilities disaggregated by sex (s), single year intervals (P) and single year of birth cohorts (C), see Figure 13.

$$
\begin{aligned}
A = \quad & T_{s,P,C+1} + \\
& T_{s,P,C+2} + T_{s,P+1,C+2} + \\
& T_{s,P,C+3} + T_{s,P+1,C+3} + T_{s,P+2,C+3} + \\
& T_{s,P,C+4} + T_{s,P+1,C+4} + T_{s,P+2,C+4} + T_{s,P+3,C+4} + \\
& T_{s,P,C} * T_{s,P,C+1} / [T_{s,P,C+1} + T_{s,P,C-1}] + \\
& T_{s,P+1,C+1} * T_{s,P+1,C+2} / [T_{s,P+1,C+2} + T_{s,P+1,C}] + \\
& T_{s,P+2,C+2} * T_{s,P+2,C+3} / [T_{s,P+2,C+3} + T_{s,P+2,C+1}] + \\
& T_{s,P+3,C+3} * T_{s,P+3,C+4} / [T_{s,P+3,C+4} + T_{s,P+3,C+2}] + \\
& T_{s,P+4,C+4} * T_{s,P+4,C+5} / [T_{s,P+4,C+5} + T_{s,P+4,C+3}]
\end{aligned}
$$

and

$$
\begin{aligned}
B = \quad & T_{s,P+4,C+3} + \\
& T_{s,P+3,C+2} + T_{s,P+4,C+2} + \\
& T_{s,P+2,C+1} + T_{s,P+3,C+1} + T_{s,P+4,C+1} + \\
& T_{s,P+1,C} + T_{s,P+2,C} + T_{s,P+3,C} + T_{s,P+4,C} + \\
& T_{s,P,C} * T_{s,P,C-1} / [T_{s,P,C+1} + T_{s,P,C-1}] + \\
& T_{s,P+1,C+1} * T_{s,P+1,C} / [T_{s,P+1,C+2} + T_{s,P+1,C}] + \\
& T_{s,P+2,C+2} * T_{s,P+2,C+1} / [T_{s,P+2,C+3} + T_{s,P+2,C+1}] + \\
& T_{s,P+3,C+3} * T_{s,P+3,C+2} / [T_{s,P+3,C+4} + T_{s,P+3,C+2}] + \\
& T_{s,P+4,C+4} * T_{s,P+4,C+3} / [T_{s,P+4,C+5} + T_{s,P+4,C+3}] + \\
& \Sigma_{P...P+4}\, \Sigma_{C-n...C-1}\, T_{s,P,C}
\end{aligned}
$$

The sole change from the equations for 5<=a<=70 is the addition of the final term under component B.

Again, more economically:

$$A = \sum_{x=0}^{x=3} \sum_{y=x+1}^{y=4} T_{p+x,c+y} + \sum_{x=0}^{x=4} T_{p+x,c+x} \left[\frac{T_{p+x,c+x+1}}{T_{p+x,c+x+1} + T_{p+x,c+x-1}} \right]$$

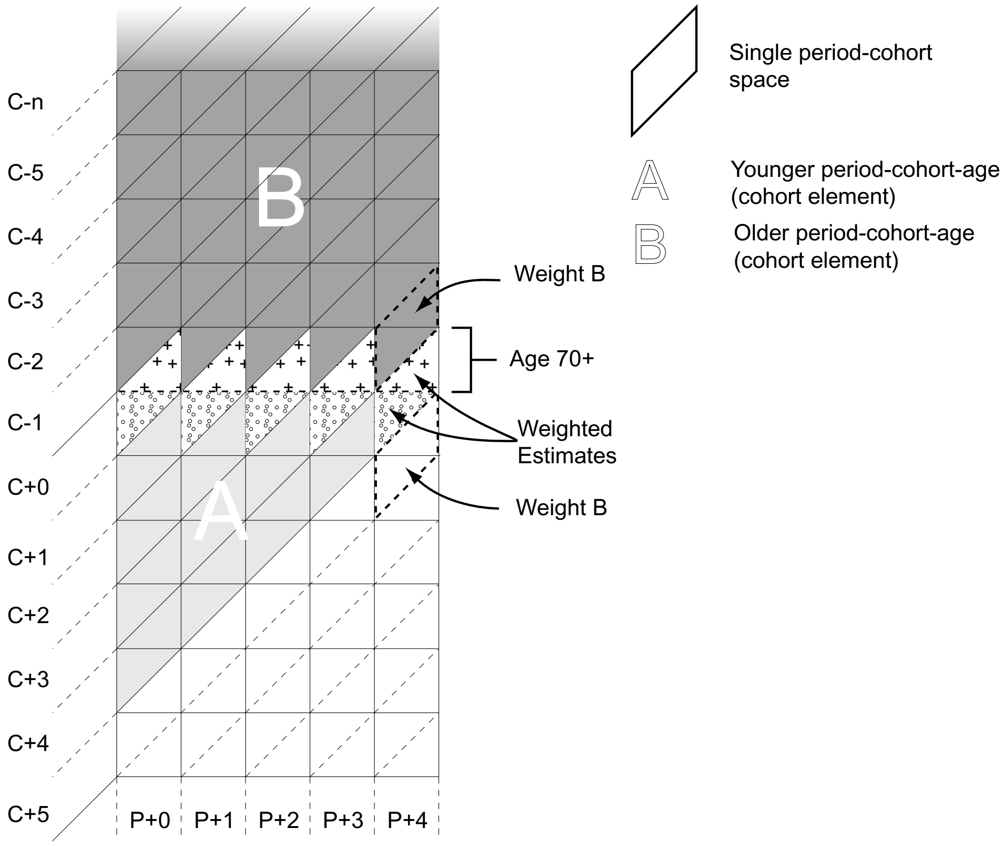
and

$$B = \sum_{x=1}^{x=4} \sum_{y=0}^{y=x-1} T_{p+x,c+y} + \sum_{x=0}^{x=4} T_{p+x,c+x} \left[\frac{T_{p+x,c+x-1}}{T_{p+x,c+1} + T_{p+x,c+x-1}} \right] + \sum_{x=0}^{x=4} \sum_{y=-\infty}^{y=-1} T_{p+x,c+y}$$

which may be rewritten

$$B = \sum_{x=0}^{x=4} \sum_{y=-\infty}^{y=x-1} T_{p+x,c+y} + \sum_{x=0}^{x=4} T_{p+x,c+x} \left[\frac{T_{p+x,c+x-1}}{T_{p+x,c+1} + T_{p+x,c+x-1}} \right]$$

Figure 13: Calculation of separation factors to split period-cohort flows for population aged 75+ at the end of the interval between older and younger period-cohort spaces, Australia



for a=0

Similarly, special procedures are also needed to estimate migration of the cohort born during the intercensal period. This is needed to calculate aggregate migration for the youngest age group (a=0). One component of the migration of this group has already been estimated via the first set of separation factors set out above. This represents the movements that occurred at ages 0-4 to the cohort born during the previous intercensal period and is given by the equation S_{spca} where a=0. To this must be added the movements of the cohort born during the current intercensal period (p). Since no data are available from the Census on the migration of this intercensal birth cohort, they must be estimated by reference to the movement of the next youngest cohort – those born during intercensal period p-1. The estimate can be made using the same approach adopted for other age groups, as set out above. First, however, we require estimates of the migration probabilities for the birth cohort in each single year interval of the intercensal period, since these are also missing from the Census transition measure. For simplicity these can be set to half the value of the previous single year cohort. Thus, for C=0:

$$R_{s,P,C} = R_{s,P,C-1} / 2$$

The equations on which to estimate moves by the intercensal birth cohort then follow:

$$\begin{aligned} A` = \; & R_{s,P,C-5} + R_{s,P+1,C-5} + R_{s,P+2,C-5} + R_{s,P+3,C-5} + R_{s,P+4,C-5} + \\ & R_{s,P,C-4} + R_{s,P+1,C-4} + R_{s,P+2,C-4} + R_{s,P+3,C-4} + R_{s,P+4,C-4} + \end{aligned}$$

$$R_{s,P,C-3} + R_{s,P+1,C-3} + R_{s,P+2,C-3} + R_{s,P+3,C-3} + R_{s,P+4,C-3} +$$
$$R_{s,P,C-2} + R_{s,P+1,C-2} + R_{s,P+2,C-2} + R_{s,P+3,C-2} + R_{s,P+4,C-2} +$$
$$R_{s,P,C-1} + R_{s,P+1,C-1} + R_{s,P+2,C-1} + R_{s,P+3,C-1} + R_{s,P+4,C-1}$$

or

$$A = \sum_{x=0}^{x=4} \sum_{y=-1}^{y=-5} R_{p+x,c+y}$$

and

$$B` = R_{s,P+4,C+3} +$$
$$R_{s,P+3,C+2} + R_{s,P+4,C+2} +$$
$$R_{s,P+2,C+1} + R_{s,P+3,C+1} + R_{s,P+4,C+1} +$$
$$R_{s,P+1,C} + R_{s,P+2,C} + R_{s,P+3,C} + R_{s,P+4,C} +$$
$$R_{s,P,C} + R_{s,P+1,C+1} + R_{s,P+2,C+2} + R_{s,P+3,C+3} + R_{s,P+4,C+4}$$

or

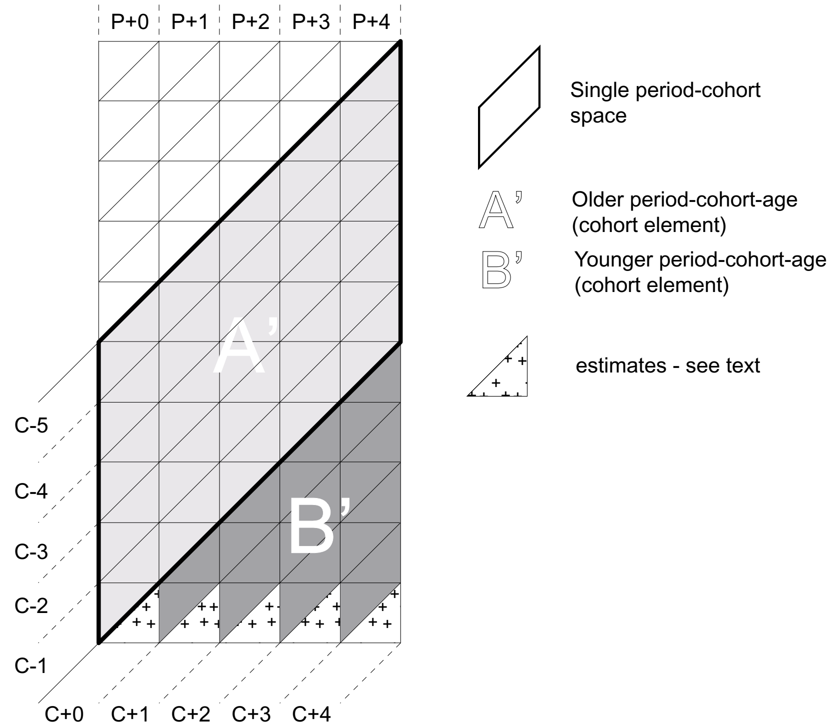
$$B = \sum_{x=0}^{x=4} \sum_{y=0}^{y=x} R_{p+x,c+y}$$

Then

$$S`_{spca} = B`/A`$$

There are two key differences between this equation for the intercensal birth cohort and that for earlier cohorts set out above. First, the value A` represents all moves made by the cohort born during the previous intercensal period. Secondly, in this case S` represents a multiplier, rather than a separation factor. In practice, however, it is convenient to incorporate this multiplier in a common matrix with the separation factors for other age groups. (Figure14).

Figure 14: Calculation of multiplier to estimate migration by inter-censal birth cohort, Australia



The separation factors were derived by Excel spreadsheets and are held in d:\arc\data\tsd\interpol.xls. The results are tabulated in Tables 8 and 9.

Table 8: Separation factors for males, Australia

age at start of interval	age at end of interval	1976-81			1981-86		
		birth cohort	separation factors		birth cohort	separation factors	
			younger age group	older age group		younger age group	older age group
births	0-4	1976-81	0.6266		1981-86	0.6219	
0-4	5-9	1971-76	0.5604	0.4396	1976-81	0.5553	0.4447
5-9	10-14	1966-71	0.5411	0.4589	1971-76	0.5340	0.4660
10-14	15-19	1961-66	0.4264	0.5736	1966-71	0.4373	0.5627
15-19	20-24	1956-61	0.3558	0.6442	1961-66	0.3727	0.6273
20-24	25-29	1951-56	0.5478	0.4522	1956-61	0.5373	0.4627
25-29	30-34	1946-51	0.5690	0.4310	1951-56	0.5618	0.4382
30-34	35-39	1941-46	0.5461	0.4539	1946-51	0.5457	0.4543
35-39	40-44	1936-41	0.5433	0.4567	1941-46	0.5443	0.4557
40-44	45-49	1931-36	0.5319	0.4681	1936-41	0.5318	0.4682
45-49	50-54	1926-31	0.5240	0.4760	1931-36	0.5272	0.4728
50-54	55-59	1921-26	0.5155	0.4845	1926-31	0.5149	0.4851
55-59	60-64	1916-21	0.4908	0.5092	1921-26	0.5045	0.4955
60-64	65-69	1911-16	0.5065	0.4935	1916-21	0.5237	0.4763
65-69	70-74	1906-11	0.5106	0.4894	1911-16	0.5263	0.4737
70+	75+	pre 1906	0.2697	0.7303	pre 1911	0.2679	0.7321
			1986-91			1991-96	
births	0-4	1986-91	0.6272		1991-96	0.6282	
0-4	5-9	1981-86	0.5562	0.4438	1986-91	0.5591	0.4409
5-9	10-14	1976-81	0.5288	0.4712	1981-86	0.5277	0.4723
10-14	15-19	1971-76	0.4382	0.5618	1976-81	0.4343	0.5657
15-19	20-24	1966-71	0.3806	0.6194	1971-76	0.3892	0.6108
20-24	25-29	1961-66	0.5262	0.4738	1966-71	0.5216	0.4784
25-29	30-34	1956-61	0.5548	0.4452	1961-66	0.5532	0.4468
30-34	35-39	1951-56	0.5465	0.4535	1956-61	0.5490	0.4510
35-39	40-44	1946-51	0.5412	0.4588	1951-56	0.5405	0.4595
40-44	45-49	1941-46	0.5296	0.4704	1946-51	0.5302	0.4698
45-49	50-54	1936-41	0.5237	0.4763	1941-46	0.5216	0.4784
50-54	55-59	1931-36	0.5099	0.4901	1936-41	0.5097	0.4903
55-59	60-64	1926-31	0.5040	0.4960	1931-36	0.5060	0.4940
60-64	65-69	1921-26	0.5083	0.4917	1926-31	0.5076	0.4924
65-69	70-74	1916-21	0.5042	0.4958	1921-26	0.5010	0.4990
70+	75+	pre 1916	0.2529	0.7471	pre 1921	0.2510	0.7490

Table 9: Separation factors for females, Australia

age at start of interval	age at end of interval	1976-81 birth cohort	1976-81 separation factors younger age group	1976-81 separation factors older age group	1981-86 birth cohort	1981-86 separation factors younger age group	1981-86 separation factors older age group
births	0-4	1976-81	0.6221		1981-86	0.6144	
0-4	5-9	1971-76	0.5611	0.4389	1976-81	0.5552	0.4448
5-9	10-14	1966-71	0.5391	0.4609	1971-76	0.5356	0.4644
10-14	15-19	1961-66	0.3748	0.6252	1966-71	0.3903	0.6097
15-19	20-24	1956-61	0.4153	0.5847	1961-66	0.4112	0.5888
20-24	25-29	1951-56	0.5816	0.4184	1956-61	0.5697	0.4303
25-29	30-34	1946-51	0.5649	0.4351	1951-56	0.5633	0.4367
30-34	35-39	1941-46	0.5495	0.4505	1946-51	0.5515	0.4485
35-39	40-44	1936-41	0.5416	0.4584	1941-46	0.5415	0.4585
40-44	45-49	1931-36	0.5233	0.4767	1936-41	0.5273	0.4727
45-49	50-54	1926-31	0.5143	0.4857	1931-36	0.5184	0.4816
50-54	55-59	1921-26	0.4997	0.5003	1926-31	0.5125	0.4875
55-59	60-64	1916-21	0.4981	0.5019	1921-26	0.5156	0.4844
60-64	65-69	1911-16	0.5153	0.4847	1916-21	0.5267	0.4733
65-69	70-74	1906-11	0.5036	0.4964	1911-16	0.5116	0.4884
70+	75+	pre 1906	0.1954	0.8046	pre 1911	0.1960	0.8040
			1986-91			1991-96	
births	0-4	1986-91	0.6224		1991-96	0.6262	
0-4	5-9	1981-86	0.5553	0.4447	1986-91	0.5598	0.4402
5-9	10-14	1976-81	0.5310	0.4690	1981-86	0.5290	0.4710
10-14	15-19	1971-76	0.3921	0.6079	1976-81	0.3909	0.6091
15-19	20-24	1966-71	0.4130	0.5870	1971-76	0.4187	0.5813
20-24	25-29	1961-66	0.5571	0.4429	1966-71	0.5508	0.4492
25-29	30-34	1956-61	0.5609	0.4391	1961-66	0.5616	0.4384
30-34	35-39	1951-56	0.5509	0.4491	1956-61	0.5535	0.4465
35-39	40-44	1946-51	0.5396	0.4604	1951-56	0.5391	0.4609
40-44	45-49	1941-46	0.5237	0.4763	1946-51	0.5207	0.4793
45-49	50-54	1936-41	0.5108	0.4892	1941-46	0.5085	0.4915
50-54	55-59	1931-36	0.5044	0.4956	1936-41	0.5048	0.4952
55-59	60-64	1926-31	0.5037	0.4963	1931-36	0.5007	0.4993
60-64	65-69	1921-26	0.5055	0.4945	1926-31	0.5048	0.4952
65-69	70-74	1916-21	0.4874	0.5126	1921-26	0.4865	0.5135
70+	75+	pre 1916	0.1884	0.8116	pre 1921	0.1882	0.8118

5.1.2 Application of separation factors to estimate the age component of migration

The separation factors derived above were use to split the period-cohort migration values recorded in the TSD matrices into their constituent APC elements using the following equations.

Let M_{spc} be a matrix of inter-regional migration flows disaggregated by sex (s), period (p) and birth cohort (c)
Let M'_{spca} be a matrix of inter-regional migration flows disaggregated by sex (s), period (p), birth cohort (c), and age (a)
Let S_{spca} be a matrix of separation factors disaggregated by sex (s), period (p), birth cohort (c), and age (a)

Further, for ease of notation,
index p by reference to the earliest year in the five year interval
index c by reference to the earliest year of the birth cohort
index a by reference to the youngest age of the five year age group and define a=p-c

Then for a>=5

$M'_{s,p,c,a} = M_{s,p,c} * S_{s,p,c,a}$
and
$M'_{s,p,c,a-5} = M_{s,p,c} * S_{s,p,c,a-5}$

and for a=0

$M'_{s,p,c,a} = M_{s,p,c-5} * S_{s,p,c,a}$

In order to ensure integer values that sum to the original period-cohort migration values, these equations may be rewritten as:

$M'_{s,p,c,a} = (M_{s,p,c} * S_{s,p,c,a})$

and
$M'_{s,p,c,a-5} = M_{s,p,c} - M'_{s,p,c,a}$

and for a=0

$M'_{s,p,c,a} = M_{s,p,c-5} * S_{s,p,c,a}$

5.1.3 Implementation

The code for creating the APC database is written in Visual Basic and stored within a Visual Basic project called OZAPC.vbp. As discussed above, the aim was create a direct link between the source MDL files and the APC database by calculating the number of transitions associated with each APC element and associated these values with the following set of codes;

- origin code
- destination code
- age code (age at occurrence)
- sex code
- period code

- birth-cohort code
- period-cohort code
- age-period-cohort code
- estimate of the number of transitions (enumerated persons)
-

Each record in the input MDL file already contains the origin, destination, sex and period codes and the associated number of transitions. It also contains an 'age' code but this code, as it appears in the MDL record, actually measures age at the end of the period, rather than age at occurrence of migration. This end of period age code therefore really represents a period-cohort flow. One of the tasks that is required therefore is a translation of this 'age' code into a period-cohort code, and the estimation of a new age code which reflects age at occurrence of migration. In addition, we need to split each period-cohort flow into its constituent APC elements (and assign them the appropriate APC codes), and also assign appropriate birth-cohort codes.

These tasks were subdivided into the following set of procedures:

- scrutinise each record in the MDL input file and discarded all records except those which involved a change of residence between two of the 69 TSDs (section 5.1.3.1).
- segment each period-cohort migration flow into its two APC elements based on the series of pre-calculated separation factors and assign codes for these Age-Period-Cohort elements (section 5.1.3.2).
- assign birth cohort codes to each APC element (section 5.1.3.3)
- assign period-cohort codes to each APC element (section 5.1.3.4).
- assign period-age codes to each APC element based on age group, which is the Census age at the end of the period (section 5.1.3.4)
- recodes to match the British database (section 5.1.3.5).
- output flows and codes assigned to each APC element as a single record in a comma delimited ASCII file (section 5.1.3.6)

The relationship between birth-cohort, period-cohort and age-period-cohort is described in Figure 15. The coding systems for age-period-cohort, period cohorts and age period spaces are shown in Figure 16.

The reader will realise that the content of Figures 15 and 16 correspond with the information provided in Figures 1 through 5. However, the information is presented here in an alternative format which further helps th clarify the concepts.

Figure 15: Age-Period-Cohort plan of TSD flow matrices with code identifiers

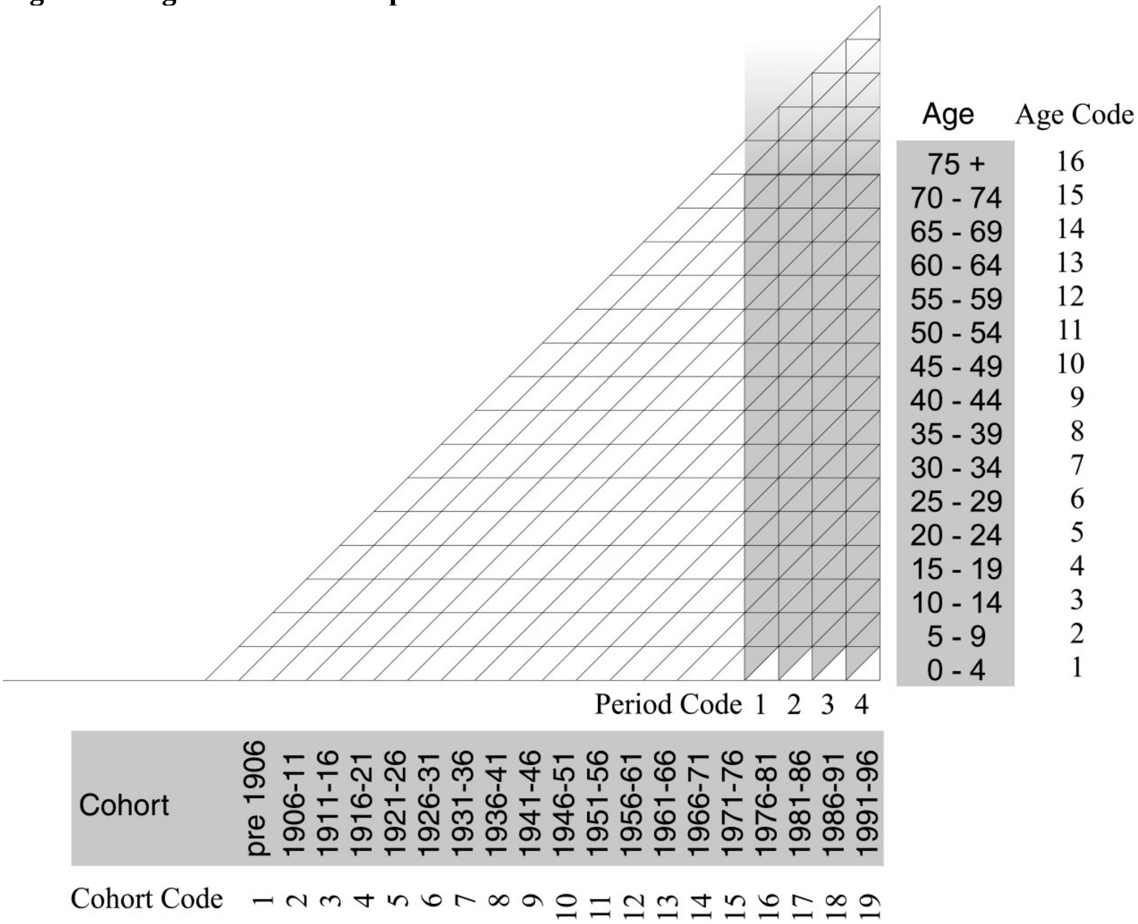
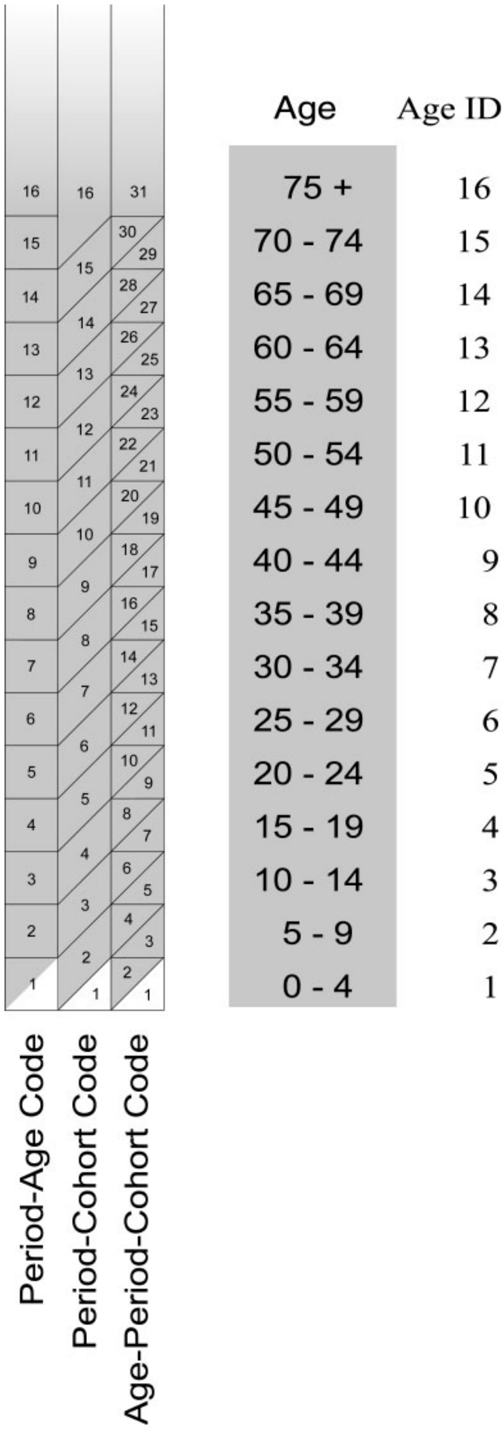


Figure 16: APC and PC codes



5.1.3.1 Removal of irrelevant MDL records

Within the source data file there are several records which are not required. Because only limited imputation is carried out for the migration indicator and for place of usual residence five years ago, census coding and classification procedures provide a range of special purpose categories for people who had no usual residence five years prior to the Census or whose place of residence could not be adequately identified. These include those who people:

- who failed to state their previous usual residence (several sub-codes)
- were overseas at the time of the previous Census
- were born during the intercensal period

These records need to be filtered from the data set. This is a chieved by first reading all of the MDL records into a storage array, which contains the initial data set out in Table 10.

Table 10: MDL storage array

Field	Variable
1	Sex
2	Age
3	mi recoded movement indicator
4	SDUR5 (Origin TSD codes)
5	SDUR (Destination TSD codes)
6	tally (persons)

Next this storage array is filtered, discarding all records except those, which involved a change of residence between two of the 69 TSDs. As the TSDs are coded 1 to 69 with all the additional information given codes above 69, it is simply a matter of using a conditional statement to remove these records. The MDL file also contains information on movers, non-movers and migrants born during the intercensal period within each TSD. These records are not required for creation of the flow matrix, although they are used in creation of the population at risk (PAR), as discussed in a later section. This set of records is removed from the current process by checking if the origin and destination TSD codes are the same.

5.1.3.2 Creation of APC elements and assignment of APC codes

Each record in the MDL file represents the number of persons who moved in a particular period. These moves occur within a period-cohort space. Each of these period-cohort spaces can be subdivided by applying the separation factors calculated as described earlier. The separation factors are stored in an array, which is indexed by age group (age at end of period), sex and period (Table 11). The transitions associated with each MDL record are multiplied by the relevant separation factor (identified by period, sex and age indexes) which provides an estimate of the number of transitions that occurred within a lower/younger age-period-cohort space. The upper/older APC elements are calculated by subtracting the lower/younger APC element from the original MDL period-cohort transitions. An exception is the birth APC element. In this case there are no figures for the numbers of people born during the period who moved in the 0-4 age group, so they are estimated from the 5-9 age group using a further set of separation factors. This estimate is implemented as a conditional statement in the main processing loop. In simple terms three APC elements, lower/younger, upper/older and a birth APC element are derived from the 5-9 age group transitions.

Source calculations for the separation factors are stored in Sep_Fact_Calc.xls located in H:\work\popdyn\migration\MigDB

An *age-period-cohort code* is assigned dependant on the age code of the record (age at end of period) and whether it is the lower/younger or upper/older APC element. In effect, end of period age code and APC element type are used as indexes to the look-up table set out in Table 12. It should be noted here that these look-up tables are indexed by age at the end of the period, which is the age code that exists on the original flow record.

Table 11: Lower/Younger APC element separation factors, Australia

	Age at end of period	Age ID	1976-81	1981-86	1986-91	1991-96
MALE	0-4	1	0.626556	0.621873	0.627204	0.628223
	5-9	2	0.560398	0.555286	0.556158	0.559133
	10-14	3	0.541116	0.533986	0.528817	0.527691
	15-19	4	0.426363	0.437331	0.438200	0.434320
	20-24	5	0.355751	0.372673	0.380627	0.389199
	25-29	6	0.547831	0.537281	0.526179	0.521595
	30-34	7	0.569023	0.561839	0.554801	0.553231
	35-39	8	0.546084	0.545656	0.546544	0.548964
	40-44	9	0.543262	0.544331	0.541248	0.540471
	45-49	10	0.531929	0.531831	0.529575	0.530238
	50-54	11	0.524001	0.527190	0.523697	0.521561
	55-59	12	0.515462	0.514903	0.509946	0.509734
	60-64	13	0.490753	0.504461	0.504001	0.506038
	65-69	14	0.506522	0.523673	0.508340	0.507615
	70-74	15	0.510631	0.526307	0.504242	0.501016
	75+	16	0.269736	0.267911	0.252891	0.250966
FEMALE	0-4	1	0.622118	0.614362	0.622385	0.626209
	5-9	2	0.561148	0.555239	0.555341	0.559828
	10-14	3	0.539111	0.535630	0.531024	0.529035
	15-19	4	0.374771	0.390335	0.392119	0.390920
	20-24	5	0.415290	0.411222	0.413008	0.418699
	25-29	6	0.581624	0.569702	0.557143	0.550841
	30-34	7	0.564851	0.563324	0.560874	0.561616
	35-39	8	0.549517	0.551484	0.550859	0.553461
	40-44	9	0.541604	0.541520	0.539648	0.539123
	45-49	10	0.523259	0.527292	0.523710	0.520744
	50-54	11	0.514319	0.518398	0.510817	0.508504
	55-59	12	0.499748	0.512516	0.504421	0.504754
	60-64	13	0.498148	0.515609	0.503679	0.500718
	65-69	14	0.515304	0.526692	0.505462	0.504836
	70-74	15	0.503593	0.511635	0.487374	0.486479
	75+	16	0.195362	0.196030	0.188394	0.188195

Table 12: APC code look-up table, Australia

Age ID	Younger APC space (the 'down' cohort element)	Older APC space (the 'up' cohort element)
1	*1**	2
2	3	4
3	5	6
4	7	8
5	9	10
6	11	12
7	13	14
8	15	16
9	17	18
10	19	20
11	21	22
12	23	24
13	25	26
14	27	28
15	29	30
16	31	-

** there are no 5 year transitions in the 0-4 age group. The APC element 1 flows are estimated from the 5-9 age group*

5.1.3.3 Translation from Census age to birth cohort

Table 13 sets out the coding used to translate age recorded at the Census to the appropriate birth cohort and hence to a consistent numeric code. Numbering is from left to right with the earliest cohort identified being those born prior to 1906. Although the earliest cohort that can be identified from the 1996 Census data is that born prior to 1921, this approach minimises data loss. The pre-1906 birth cohort are coded as birth cohort 1 and the youngest cohort in the data base are those born between 1991 and 1996 who are accorded code 19. The latter group only appears in data for the 1991-96 migration interval. This is depicted graphically in Figure 15, where the diagonal lines represent the boundaries between different 5 year cohorts.

Within the program this translation is achieved by using another look-up table indexed by period and age group code (age at end of period). For each age group there is a corresponding numeric value which when summed with the period value (1, 2, 3 or 4) gives the required birth cohort code. As the program loops through each of the MDL records the birth cohort code is calculated and assigned to the appropriate field in the output array.

Table 13: Assignment of birth cohort codes, Australia

Age at end of interval	1976-81 period		1981-86 period		1986-91 period		1991-96 period	
	birth cohort	Code	Birth Cohort	Code	Birth Cohort	Code	Birth cohort	code
0-4	1976-81	16	1981-86	17	1986-91	18	1991-96	19
5-9	1971-76	15	1976-81	16	1981-86	17	1986-91	18
10-14	1966-71	14	1971-76	15	1976-81	16	1981-86	17
15-19	1961-66	13	1966-71	14	1971-76	15	1976-81	16
20-24	1956-61	12	1961-66	13	1966-71	14	1971-76	15
25-29	1951-56	11	1956-61	12	1961-66	13	1966-71	14
30-34	1946-51	10	1951-56	11	1956-61	12	1961-66	13
35-39	1941-46	9	1946-51	10	1951-56	11	1956-61	12
40-44	1936-41	8	1941-46	9	1946-51	10	1951-56	11
45-49	1931-36	7	1936-41	8	1941-46	9	1946-51	10
50-54	1926-31	6	1931-36	7	1936-41	8	1941-46	9
55-59	1921-26	5	1926-31	6	1931-36	7	1936-41	8
60-64	1916-21	4	1921-26	5	1926-31	6	1931-36	7
65-69	1911-16	3	1916-21	4	1921-26	5	1926-31	6
70-74	1906-11	2	1911-16	3	1916-21	4	1921-26	5
75+	pre 1906	1	Pre 1911	2	pre 1916	3	pre 1921	4

5.1.3.4 Assignment of Period-Cohort and Period-Age codes

As Figure 16 shows, the flows in each period can be divided up in three different ways, the period-age space, the period cohort space and the age-period-cohort space. Even though each of these different spaces can be uniquely referenced by a combination of the period and APC codes, it facilitates later analysis if unique codes are assigned for each of these three spaces.

The *period-age code* is derived from the end of period age code. As each APC element is calculated from the period-cohort transitions, the lower/younger APC element is assigned a period-age code of 1 minus the end of period age code. For example, the lower/younger APC element of the 5-9 transitions (end of period age code = 2) is assigned a period-age code of 1. The upper/older APC elements are not changed: they are simply assigned the end of period age code. The birth APC element is the single exception, in that no end of period code exists in the input data set. In this case, every birth APC element is simple assigned a period-age code of 1.

As the end of period age code also represents the *period-cohort code*, creating the period-cohort code is a simple procedure of assigning the end of period code to the period-cohort code. As with the APC codes the birth APC element is the exception, in that no end of period code exists in the input data set. In this case, every birth APC element is simply assigned a period-cohort code of 1.

5.1.3.5 Recodes to match the British database

While the separation factors derived earlier split the group aged 75 and over at the end of the period to identify APC elements 30 and 31 (see Figure 15 & Figure 16), it is difficult to derive corresponding Populations at Risk (PARs) for element 31 from the available data. Moreover, this split was not required for comparison with the British database, which simply splits the 70-74 Period-Age space into APC elements 29 and 30. Therefore, for comparison purposes, Australian APC elements 30 and 31 were combined by recoding element 31 as element 30. Similarly, period-age code 16 was recoded to a value of 15.

5.1.3.6 Format and coding of the resulting data base

The output from the Visual Basic routines is similar to the input MDL files, each record representing an APC element composed of a group of enumerated persons who are defined by a preceding set of coded attributes. In this case, there are eight sets of codes located in the first eight fields, the ninth field holding an estimate of the number of transitions that occur in the APC element. The nine sequential fields are set out in Table 14

Table 14: Coding structure for APC Flow database, Australia

Field	Type	Variable
1	Integer	Origin TSD
2	Integer	Destination TSD
3	Integer	Sex
4	Integer	Age (period-age)
5	Integer	Period
6	Integer	Cohort (birth cohort)
7	Integer	period-cohort
8	Integer	age-period-cohort
9	real	tally

5.2 Age-period-cohort processing of migration data in Britain

At this stage we have generated one set of files containing the ODAS arrays specified as 35 origins by 35 destinations by ages by 2 sexes for 20 mid-year to mid-year periods. However, the 1976-77 to 1982-83 files classify migration by five-year ages, whereas the 1983-84 to 1995-96 files classify migration by single years of age. In both cases the period-age observation plan is use. To estimate migration flows for each age-period-cohort space, we need slightly different schemes for each five-year time interval. In 1976-81 only five year age group data are input; in 1981-86 both five year and one year of age data are input; for 1986-91 and 1991-96 only one year of age data are input. These three cases are considered in turn.

5.2.1 A general notation

Let M(a,p,c) = migrations by 5 year period-age a, 5 year period p and 5 year birth cohort c. M(a,p) are the migrations by five year period-age a and five year period p. We index the single years of age within a five year age group as a+0, ... , a+4 and the single year time intervals within a five year period as p+0, ... , p+4. We identify the earlier birth cohort that contributes to the period-age the down APC, using the notation c=d and the later birth cohort as the up APC, using the notation c=u.

5.2.2 The method for the period 1976-81

The migrations in the older cohort or down APC for each period-age are estimated thus:

M(a,p,c=d) =
0.9*M(a,p+0)+0.7*M(a,p+1)+0.5*M(a,p+2)+0.3*M(a,p+3)+0.1*M(a,p+4)

The migrations in the later cohort or up APC for each period-age are estimated thus:

M(a,p,c=u) =
0.1*M(a,p+0)+0.3*M(a,p+1)+0.5*M(a,p+2)+0.7*M(a,p+3)+0.9*M(a,p+4)

Figure 17A shows the age-year weights used in these equations for period 1976-81.

5.2.3 The method for the periods 1986-91 and 1991-96

The migrations in the older cohort or down APC for each period-age are estimated thus:

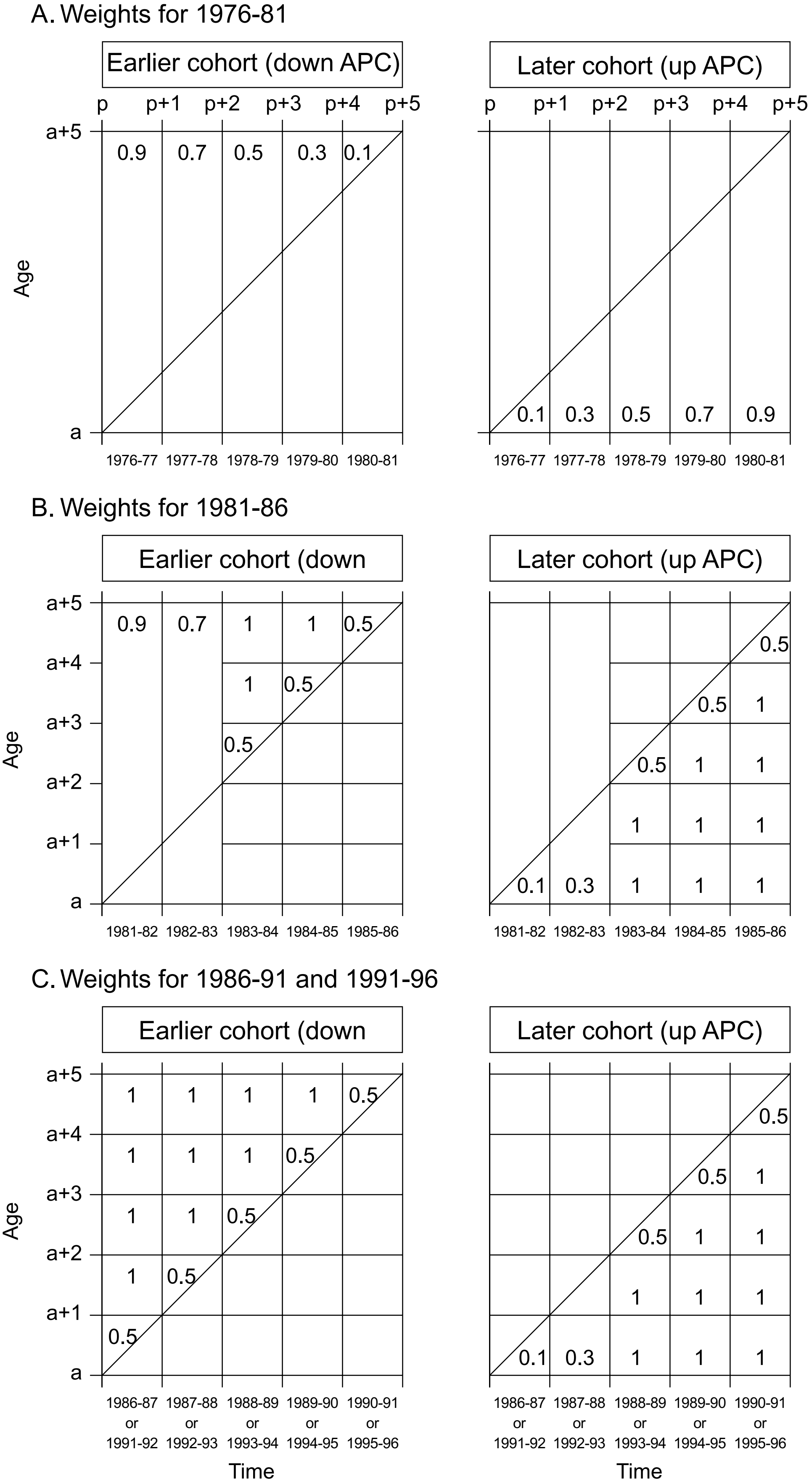
$$
\begin{aligned}
M(a,p,c=d) = {} & 0.5*M(a+0,p+0)+M(a+1,p+0)+M(a+2,p+0)+M(a+3,p+0)+M(a+4,p+0) \\
& +0.5*M(a+1,p+1)+M(a+2,p+1)+M(a+3,p+1)+M(a+4,p+1) \\
& +0.5*M(a+2,p+2)+M(a+3,p+2)+M(a+4,p+2) \\
& +0.5*M(a+3,p+3)+M(a+4,p+3) \\
& +0.5*M(a+4,p+4)
\end{aligned}
$$

The migrations in the later cohort or up APC for each period-age are estimated thus:

$$
\begin{aligned}
M(a,p,c=u) = {} & +0.5*M(a+0,p+0) \\
& +0.5*M(a+1,p+1)+M(a+0,p+1) \\
& +0.5*M(a+2,p+2)+M(a+1,p+2)+M(a+0,p+2) \\
& +0.5*M(a+3,p+3)+M(a+2,p+3)+M(a+1,p+3)+M(a+0,p+3) \\
& +0.5*M(a+4,p+4)+M(a+3,p+4)+M(a+2,p+4)+M(a+1,p+4)+M(a+0,p+4)
\end{aligned}
$$

Figure 17C shows the age-year weights used in these equations for periods 1986-91 and 1991-96.

Figure 17 Weights for processing migration flows by period-ages into age-period-cohort spaces, British migration data



5.2.4 The method for the period 1981-86

Figure 17B shows that for 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 migrations in the older cohort or down APC for each period-age are estimated thus:

$$
\begin{aligned}
M(a,p,c{=}d) = {} & 0.9*M(a,p+0) \\
& +0.7*M(a,p+1) \\
& +0.5*M(a+2,p+2)+M(a+3,p+2)+M(a+4,p+2) \\
& +0.5*M(a+3,p+3)+M(a+4,p+3) \\
& +0.5*M(a+4,p+4)
\end{aligned}
$$

The migrations in the later cohort or up APC for each period-age are estimated thus:

$$
\begin{aligned}
M(a,p,c{=}u) = {} & 0.1*M(a,p+0) \\
& +0.3*M(a,p+1) \\
& +0.5*M(a+2,p+2)+M(a+1,p+2)+M(a+0,p+2) \\
& +0.5*M(a+3,p+3)+M(a+2,p+3)+M(a+1,p+3)+M(a+0,p+3) \\
& +0.5*M(a+4,p+4)+M(a+3,p+4)+M(a+2,p+4)+M(a+1,p+4)+M(a+0,p+4)
\end{aligned}
$$

5.2.5 The method for the last APC

These equations are applied to a=0-4, ... , 70-74, with one modification. The final APC space (number 30 in Figure 5) is an open-ended trapezium. We add the migrations of the down APC for ages 70-74 to all migrations for age 75+:

$$M(a{=}70{+},p,c{=}d) = M(a{=}70\text{-}74,p,c{=}d) + M(a{=}75{+},p)$$

5.3 Software used

The compilation of the data files described in section 4.2 into a single data file was originally performed using a Visual Basic program called AgePeriodCohort. A Fortran 90 program called apc replicated the functions of the Visual Basic program, correcting some faults and implementing some revised specifications, and also adding some additional features. The source code for these programs is located in the directories

```
/data/wallace_1/migdata/programs/AgePeriodCohort
```

and

```
/data/wallace_1/migdata/programs/apc
```

6. Populations at risk

In previous sections, we have shown how the migration time series in Australia and Britain have been processed into a parallel set of inter-regional flows classified by age, period and cohort for five year intervals. We now need to define how to use the migration flow data to compute migration intensities. To do this we need to specify the populations at risk corresponding to the age-period-cohort flows. We begin by defining some general concepts and then provide details for the transition concept populations at risk for Australia and the movement concept populations at risk for Britain.

By *intensity*, we mean the general term to measure the propensity of migrate between places, irrespective of the type of migration data being used. Note that the methods of intensity computation should give the same results when the age and time intervals are infinitesimally small. Table 15 sets out the choices for intensities and populations at risk.

Table 15: Migration intensities and populations at risk: the choices

Country	Occurrence-exposure rate	Transition probability
Australia	Not appropriate because intermediate moves not counted	Best: matches migration concept. Use start of period populations/total within country survivors
United Kingdom	Best: matches migration concept. Use average populations in a period.	Not appropriate because intermediate moves are counted

The table argues that in the Australian case, the most appropriate migration intensities are transition probabilities, whereas in the UK case the most appropriate migration intensities are occurrence-exposure rates. Each of these cases is considered in turn.

6.1 Derivation of populations at risk for the transition case: Australian migration data

In order to calculate migration intensities it is necessary to compute the relevant populations at risk of migration for each of the various age-period-cohort (APC) migration flows. For transition data, as provided by the census, migration intensities should be calculated as probabilities, based on the population at risk (PAR) at the start of the transition interval. Elsewhere we have argued that such probabilities should be conditional on survival and remaining within the country (Rees, Bell, Duke-Williams and Blake 1999). That is, the population at risk consists of two components: internal movers (those who made an inter-regional transition during the observation period) and stayers (those who were in the same region at the start and end of the observation period). International immigrants and people who died during the interval should be excluded. Data on emigrants, in any event are not available. Origin-destination matrices from the Australian Census distinguish each of these components so that, for most age groups, these PARs can be derived directly. Care is needed, however, in identifying the appropriate PAR for each APC space.

6.1.1 Defining the population at risk and computing transition probabilities

The PAR varies according to the APC space being considered. Define T(a,b) as the number of transitions occurring at age *b* to people aged *a* at the start of the transition interval. Thus, *a* represents age at the start of the interval and *b* represents the age at occurrence of migration.

Further define P(a) to represent the population at risk of migrating (making an inter-regional transition), where *a* refers to age at the start of the interval.

For analytical purposes we require PARs for four combinations of APC space: period-cohort; period-age; age-period-cohort (younger age at occurrence); and age period-cohort (older age at occurrence). The relevant APC flows and their associated PARs are set out in Table 16.

Table 16: Populations at risk from the transition perspective

Age-time observation plan	Transition variable	Population at risk (PAR)
Period-cohort	T(a,*)	P(a)
Age-period-cohort (younger age)	T(a,a)	P(a)
Age-period-cohort (older age)	T(a,a+1)	P(a)
Period-age	T(*,a)	0.5[P(a-1)]+0.5[P(a)]

Note: * denotes that the subscript covers more than one age at start or age at occurrence.

In the case of the intercensal birth cohort the transitions are measured using the definition for the older APC space but in this case the PAR is the number of births occurring during the intercensal period.

These definitions ensure consistency in calculation of intensities for PC and AP spaces and their constituent APCs.

For period-cohorts (from the table) the intensity is given by

$$T(a,*)/P(a)$$

which expands to

$$[T(a,a)+T(a,a+1)]/P(a)$$

while summing across the constituent APC spaces gives :

$$T(a,a)/P(a)+T(a,a+1)/P(a)$$

which contracts to the equivalent result

$$[T(a,a)+T(a,a+1)]/P(a)$$

And for period ages, from the table, the PA probability is given by

$$T(*,a)/\ \{0.5[P(a-1)]+0.5[P(a)]\}$$

which expands to

$$\{T(a-1,a)+T(a,a)\}/\{0.5[P(a-1)]+0.5[P(a)]\}$$

The constituent APC spaces are given by

$$T(a,a)/P(a)+T(a-1,a)/P(a-1)$$

but when calculated for more than one APC space the calculation is done by summing across all transitions and across all PARs.. Thus,

$$[T(a,a)+T(a-1,a)]/[P(a)+P(a-1)]/2$$

which delivers the equivalent result to the PA formula above.

Note that in this instance the sum of the APC intensities does not generate the same result as the PA equation, simply because the constituent APCs use different PARs. It is necessary to sum across all transitions and across all PARs before calculating the intensity. The PAR must then be averaged across the number of APC spaces involved.

Thus, it is possible to generalise the equation for computation of the intensity for any combination of adjacent APC spaces:

$$MP_{ApC} = \left[\frac{\sum_{a} \sum_{c} T_{apc}}{\sum_{a} \sum_{c} P_{apc}} \right] * \left[\frac{1}{n} \right]$$

where:

M_{ApC} is the migration intensity (probability) of migration in period p of people aged A at the time of the move, who are members of cohort C
T_{apc} are the transitions in the relevant age-period-cohort space
P_{apc} are the populations at risk (PARs) of making the corresponding transitions
a is a subset of A
c is a subset of C and
n is the number of APC spaces

Computation of the relevant probabilities can be undertaken as part of the user's analytical procedures. The crucial requirement here is to ensure that the database of populations at risk contains all the relevant values required for the calculations set out in the above table. The definitions adopted above simplify this task because they all depend on the start population in each region, disaggregated by age.

6.1.2 Deriving the PARs from the Census matrices

As noted earlier, the main diagonal of the Census origin-destination matrices includes non-movers and people who moved within the region over the transition period. The PAR for any given region *i* is therefore readily computed directly from the original matrix of origin-destination flows with elements $T_{i,j}$ as

$$PAR_i = T_{i,i} + \Sigma_{j\neq i} T_{i,j}$$

or simply

$$PAR_i = \Sigma_j T_{i,j}$$

The flow matrices identify sixteen period-cohorts. The PARs required are those at the start of the period. Thus for any age group *a*

$$PAR_{i,a,t} = \Sigma_j T_{i,j,a+5,t+5}$$

where t represents time

This is simply the origin total of a full TSD to TSD matrix, excluding those overseas at the start of the interval, those who did not state their residence at t, and those in the undefined and no usual residence categories. We need to computing the PARs is to take the end of period population totals from the full TSD matrix, excluding those overseas at the start of the interval (t), those whose usual residence at t was not stated or was undefined, and statistically move in-migrants and out-migrants back to their origins. Thus for every region k,

$$PAR_{k,a,t} = PAR_{k,a+5,t+5} + \Sigma_j T_{k,j,a+5} - \Sigma_j T_{i,k,a+5}$$

where t = time
a = age

While this procedure is computationally intensive, it has the advantage of providing a cross check on all the previous computations for the PARs and flow matrices. The T values are drawn from the the APC flow matrix and coupled with the $P_{,t+5}$ values from the original ABS flow matrix. The results can then be directly compared with the original flow matrix, as outlined at the start of this section. Any discrepancy indicates an error somewhere in the sequences of computations.

6.1.3 Estimating the size of the intercensal birth cohort

In the case of the birth cohort, estimates of interregional flows, T, have already been made in construction of the flow database. In this instance, however, we do not have a figure corresponding to the non-movers (P_{ii}) from the general equation. The format of the calculations for this group is therefore a little different, thus;

$$PAR_{,k,birth,t} = P_{k,0\text{-}4,t+5} + \Sigma_j T_{k,j,0\text{-}4,c} - \Sigma_i T_{i,k,0\text{-}4,c}$$

where

t represents time
0-4 represents the first period-cohort
c is the intercensal birth cohort

6.1.4 Coding the PARS

This procedure generates 16 populations at risk, the youngest being the intercensal birth cohort and the oldest being aged 70 and over at the start of the period. These are coded respectively from 0 to 15.

6.1.5 Structuring the PAR database

The PAR database needs to be organised in such a way that any selected inter-regional APC flow (from the flow data base) can be directly matched against the appropriate PAR. This is most readily achieved by establishing a record representing the PAR for each of the following combinations of attributes,

- TSD code
- Age group (age at occurrence) code
- Period of time code
- Birth cohort (year of birth) code
- Period-cohort code
- APC element code
- Sex code

- Tally

such that the PAR is linked to its corresponding migration flow element Thus, selection of any age/period/cohort, period-cohort, period-age or birth-cohort for a given period and sex combination should simultaneously identify the APC flows (from the flow data base) and the PARs (from the PAR database). Care is nevertheless needed in the analytical phase to ensure correct combination of flows and PARS to compute migration intensities.

6.1.6 Implementation

As in the case of the transition data a Visual Basic program was used to create the PARs at the start of each period. End of period populations, derived from the census of that period, were used as the starting point and the in and out migrations for each period-cohort were calculated from the APC database (a simple aggregation based on the period-cohort code). For each age group and for each TSD the out-migrants were added and the in-migrants were subtracted from the end of period populations.

6.2 Derivation of populations at risk for the movement case: British migration data

The PAR varies according to the APC space being considered. Define M(a,b) as the number of migrations occurring at age *b* to people aged *a* at the start of the transition interval. Thus, *a* represents age at the start of the interval and *b* represents the age at occurrence of migration. Further define P(a,t) to represent the population at risk of migrating (making an inter-regional transition), where *a* refers to age at the start of the interval, time t.

For analytical purposes we require PARs for four combinations of APC space: period-cohort; period-age; age-period-cohort (younger age at occurrence); and age period-cohort (older age at occurrence). The relevant APC flows and their associated PARs are set out in Table 17 below.

Table 17: Populations at risk from the movement perspective

Age-time observation plan	Movement variable	Population at risk (PAR)
Period-cohort	M(a,*)	0.5*[P(a,t)+P(a+1,t+1)]
Age-period-cohort (earlier cohort)	M(a,a)	0.5*[P(a,t)+0.5*{0.5{P(a,t)+P(a+1,t+1)}]
Age-period-cohort (later cohort)	M(a-1,a)	0.5*[0.5*{P(a-1,t)+P(a,t+1)}+P(a,t+1)]
Period-age	M(*,a)	0.5*[P(a,t)+P(a,t+1)]

Note: * denotes that the subscript covers more than one age at start or age at occurrence.

The movement concept, population at risk for a period-cohort is an average of the start of period population in age group a and the end of period population for age group a+1:

PAR(a,*) = 0.5*[P(a,t)+P(a+1,t+1)]

Note that we reference the end of period population as the start population of the next period.

The population at risk for the *a,a*, age-period-cohort (the earlier cohort) is:

PAR(a,a) = 0.5*[P(a,t)+0.5*{0.5{P(a,t)+P(a+1,t+1)}]

which can be simplified to

PAR(a,a) = 0.75*P(a,t)+0.25*P(a+1,t+1)

The population at risk for the *a-1,a* age-period-cohorts (the later cohort) is:

PAR(a-1,a) = 0.5*[0.5*{P(a-1,t)+P(a,t+1)}+P(a,t+1)]

which can be simplified to

PAR(a-1,a) = 0.25*P(a-1,t)+0.75*P(a,t+1)

The population at risk for a period-age is:

PAR(*,a) = 0.5*[P(a,t)+P(a,t+1)]

7. Conclusions

The finished migration age-period-cohort data and the populations at risk data for the OZ and UK are stored in the following files;

ukapc.dat	British age-period-cohort migration flows
ukpop.dat	British populations at risk
ozapc.dat	Australian age-period-cohort migration flows
ozpop.dat	Australian populations at risk

These files are located on wallace.leeds.ac.uk in the directory:

`/data/wallace_3/apcdata`

Copies of these two files are also available via the Web, from the page:

http://wallace.leeds.ac.uk/aumdb.html

This web server currently has access restricted to a number of specific domains. All those involved in the project should be able to reach the server, although anyone experiencing difficulties should contact the authors.

The structure of the two files is shown in Table 18.

Table 18: Structure of records in the British age-period-cohort database for 1976-96

MIGRATION			
File=/data/wallace_3/apcdata/ukapc.dat			
Variable	Codes	Columns	Format
Origin	Table 6	1-3	i3
Destination	Table 6	4-6	i3
Sex	Table 1	9-12	i3
Age	Table 1	13-15	i3
Period	Table 1	16-18	i3
Cohort	Table 1	19-21	i3
Period-cohort	Table 2	22-24	i3
Age-period-cohort	Table 2	25-27	i3
Migration count		28-35	f8.1
POPULATION			
File=/data/wallace_3/apcdata/ukpop.dat			
Variable	Codes	Columns	Format
Region	Table 6	1-3	i3
Sex	Table 1	4-6	i3
Age	Table 1	9-12	i3
Period	Table 1	13-15	i3
Cohort	Table 1	16-18	i3
Period-cohort	Table 2	19-21	i3
Age-period-cohort	Table 2	22-24	i3
Population count		25-34	f10.1

Table 19: Structure of records in the British age-period-cohort database for 1976-96

MIGRATION			
File=ozapc.dat			
Variable	Codes	Columns	Format
Origin	Table 5	1-3	i3
Destination	Table 5	4-6	i3
Sex	Table 1	9-12	i3
Age	Table 1	13-15	i3
Period	Table 1	16-18	i3
Cohort	Table 1	19-21	i3
Period-cohort	Table 2	22-24	i3
Age-period-cohort	Table 2	25-27	i3
Migration count		28-35	f8.1
POPULATION			
File=ozpop.dat			
Variable	Codes	Columns	Format
Region	Table 5	1-3	i3
Sex	Table 1	4-6	i3
Age	Table 1	9-12	i3
Period	Table 1	13-15	i3
Cohort	Table 1	16-18	i3
Period-cohort	Table 2	19-21	i3
Age-period-cohort	Table 2	22-24	i3
Population count		25-34	f10.1

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Appendix 1: A look-up table for TSDs to ATSDs

State	TSD	Code	ATSD	Seq	Code
NSW	Inner Sydney	101	Inner Sydney	1	101
NSW	Middle Sydney	102	Middle Sydney	2	102
NSW	Outer Sydney	103	Outer Sydney	3	103
NSW	Hunter	104	Hunter	4	104
NSW	Illawarra	105	Illawarra	5	105
NSW	Richmond-Tweed	106	North Coast	6	106
NSW	Mid-North Coast	107	North Coast	6	106
NSW	Northern	108	North West	7	107
NSW	North Western	109	North West	7	107
NSW	Central West	110	North West	7	107
NSW	South Eastern	111	South Eastern	8	108
NSW	Murrumbidgee	112	Murray-Murrum	9	109
NSW	Murray	113	Murray-Murrum	9	109
NSW	Far West	114	North West	7	107
Vic	Inner Melbourne	201	Inner Melbourne	10	210
Vic	Outer Melbourne North	202	Outer Melbourne North	11	211
Vic	Outer Melbourne South	203	Outer Melbourne South	12	212
Vic	Barwon	204	Barwon	13	213
Vic	Western Districts	205	Western Victoria	14	214
Vic	Central Highlands	206	Central Highlands	15	215
Vic	Wimmera	207	Western Victoria	14	214
Vic	Mallee	208	Western Victoria	14	214
Vic	Loddon	209	Loddon-Goulburn	16	216
Vic	Goulburn	210	Loddon-Goulburn	16	216
Vic	Ovens-Murray	211	Gippsland-Ovens	17	217
Vic	East Gippsland	212	Gippsland-Ovens	17	217
Vic	Gippsland	213	Gippsland-Ovens	17	217
Qld	Inner Brisbane	301	Inner Brisbane	18	318
Qld	Middle Brisbane	302	Middle Brisbane	19	319
Qld	Outer Brisbane	303	Outer Brisbane	20	320
Qld	Gold Coast	304	Gold Coast	21	321
Qld	Ipswich	305	Ipswich	22	322
Qld	Caboolture	306	Sunshine Coast	23	323
Qld	Wide Bay-Burnett	307	Wide Bay-Burnett	24	324
Qld	Darling Downs	308	Darling Downs	25	325
Qld	South West	309	Western	26	326
Qld	Fitzroy	310	Fitzroy-Mackay	27	327
Qld	Central West	311	Western	26	326
Qld	Mackay	312	Fitzroy-Mackay	27	327
Qld	Northern	313	North	28	328
Qld	Far North	314	North	28	328
Qld	North West	315	Western	26	326
SA	Inner Adelaide	401	Inner Adelaide	29	429
SA	Middle Adelaide	402	Middle Adelaide	30	430
SA	Outer Adelaide	403	Outer Adelaide	31	431
SA	Eyre	404	Eyre-Northern	32	432
SA	Murray Lands	405	Murray-South East	33	433
SA	Northern	406	Eyre-Northern	32	432
SA	Outer Adelaide	407	Outer Adelaide-Yorke	34	434
SA	South East	408	Murray-South East	33	433
SA	Yorke and Lower North	409	Outer Adelaide-Yorke	34	434

Appendix 1 (Continued)

State	TSD	Code	ATSD	Seq	Code
WA	Inner Perth	501	Inner Perth	35	535
WA	Middle Perth	502	Middle Perth	36	536
WA	Outer Perth	503	Outer Perth	37	537
WA	South West	504	South West	38	538
WA	Lower Great Southern	505	Midlands-Great Southern	39	539
WA	Upper Great Southern	506	Midlands-Great Southern	39	539
WA	Midlands	507	Midlands-Great Southern	39	539
WA	South Eastern	508	Central-South East	40	540
WA	Central	509	Central-South East	40	540
WA	Pilbara	510	Pilbara-Kimberley	41	541
WA	Kimberley	511	Pilbara-Kimberley	41	541
Tas	Greater Hobart	601	Hobart	42	642
Tas	Southern	602	Other Tasmania	43	643
Tas	Northern	603	Other Tasmania	43	643
Tas	Mersey-Lyell	604	Other Tasmania	43	643
NT	Darwin	701	NT	44	744
NT	NT Balance	702	NT	44	744
ACT	ACT	801	ACT	45	845

Appendix 2: Look-up table for FHSAs to new "city" regions

APC code	FHSA name	Region no.	Region name
1	Northern Ireland	35	Northern Ireland
2	Scotland	34	Scotland
3	Gateshead	29	Newcastle Rest
4	Newcastle	28	Newcastle Core
5	North Tyneside	29	Newcastle Rest
6	South Tyneside	29	Newcastle Rest
7	Sunderland	29	Newcastle Rest
8	Cleveland	30	Newcastle Near
9	Cumbria	15	Manchester Far
10	Durham	30	Newcastle Near
11	Northumberland	30	Newcastle Near
12	Barnsley	25	Sheffield Rest
13	Doncaster	25	Sheffield Rest
14	Rotherham	25	Sheffield Rest
15	Sheffield	24	Sheffield Core
16	Bradford	21	Leeds Rest
17	Calderdale	21	Leeds Rest
18	Kirklees	21	Leeds Rest
19	Leeds	20	Leeds Core
20	Wakefield	21	Leeds Rest
21	Humberside	23	Leeds Far
22	North Yorkshire	22	Leeds Near
23	Derbyshire	26	Sheffield Near
24	Leicestershire	26	Sheffield Near
25	Lincolnshire	27	Sheffield Far
26	Northamptonshire	3	London Near
27	Nottinghamshire	26	Sheffield Near
28	Cambridgeshire	3	London Near
29	Norfolk	4	London Far
30	Suffolk	3	London Near
31	L_City_Hakny_Newhm_TrHam	1	London Core
32	L_Redbridge_WalthmForest	1	London Core
33	L_Barking_Havering	1	London Core
34	L_Camden_Islington	1	London Core
35	L_Kensngtn_Chels_Wstmstr	1	London Core
36	L_Richmond_Kingston	1	London Core
37	L_Merton_Sutton_Wandswth	1	London Core
38	L_Croydon	1	London Core
39	L_Lmbth_Southwrk_Lewishm	1	London Core
40	L_Bromley	1	London Core
41	L_Bexley_Greenwich	1	London Core
42	Middlesex	1	London Core
43	Bedfordshire	3	London Near
44	Buckinghamshire	2	London Rest
45	Essex	2	London Rest
46	Hertfordshire	2	London Rest
47	Berkshire	2	London Rest
48	East Sussex	3	London Near
49	Hampshire	3	London Near
50	Isle of Wight	3	London Near

Appendix 2 (Continued)

APC code	FHSA name	Region no.	Region name
51	Kent	2	London Rest
52	Oxfordshire	3	London Near
53	Surrey	2	London Rest
54	West Sussex	3	London Near
55	Avon	5	Bristol Core
56	Cornwall	7	Bristol Far
57	Devon	7	Bristol Far
58	Dorset	7	Bristol Far
59	Gloucestershire	6	Bristol Near
60	Somerset	6	Bristol Near
61	Wiltshire	6	Bristol Near
62	Birmingham	8	Birmingham Core
63	Coventry	9	Birmingham Rest
64	Dudley	9	Birmingham Rest
65	Sandwell	9	Birmingham Rest
66	Solihull	9	Birmingham Rest
67	Walsall	9	Birmingham Rest
68	Wolverhampton	9	Birmingham Rest
69	HerefordandWorcs	10	Birmingham Near
70	Shropshire	10	Birmingham Near
71	Staffordshire	10	Birmingham Near
72	Warwickshire	10	Birmingham Near
73	Bolton	13	Manchester Rest
74	Bury	13	Manchester Rest
75	Manchester	12	Manchester Core
76	Oldham	13	Manchester Rest
77	Rochdale	13	Manchester Rest
78	Salford	13	Manchester Rest
79	Stockport	13	Manchester Rest
80	Tameside	13	Manchester Rest
81	Trafford	13	Manchester Rest
82	Wigan	13	Manchester Rest
83	Liverpool	17	Liverpool Rest
84	StHelens_Knowsley	16	Liverpool Core
85	Sefton	17	Liverpool Rest
86	Wirral	17	Liverpool Rest
87	Cheshire	14	Manchester Near
88	Lancashire	14	Manchester Near
89	Clwyd	18	Liverpool Near
90	Dyfed	33	Cardiff Far
91	Gwent	19	Liverpool Far
92	Gwynedd	11	Birmingham Far
93	Mid Glamorgan	31	Cardiff Core
94	Powys	32	Cardiff Near
95	South Glamorgan	32	Cardiff Near
96	West Glamorgan	32	Cardiff Near

Appendix 3: Look-up table linking districts to FHSAs to new "city" regions

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
01AA	City of London	46	City of London, Hackney, Newham,Tower Hamlets	1	London Core
01AB	Camden	49	Camden, Islington	1	London Core
01AC	Hackney	46	City of London, Hackney, Newham,Tower Hamlets	1	London Core
01AD	Hammersmith and Fulham	62	Ealing, Hammersmith, Hounslow	1	London Core
01AE	Haringey	57	Enfield, Haringey	1	London Core
01AF	Islington	49	Camden, Islington	1	London Core
01AG	Kensington and Chelsea	50	Kensington and Chelsea, Westminster	1	London Core
01AH	Lambeth	54	Lambeth, Southwark, Lewisham	1	London Core
01AJ	Lewisham	54	Lambeth, Southwark, Lewisham	1	London Core
01AK	Newham	46	City of London, Hackney, Newham,Tower Hamlets	1	London Core
01AL	Southwark	54	Lambeth, Southwark, Lewisham	1	London Core
01AM	Tower Hamlets	46	City of London, Hackney, Newham,Tower Hamlets	1	London Core
01AN	Wandsworth	52	Merton, Sutton, Wandsworth	1	London Core
01AP	Westminster,City of	50	Kensington and Chelsea, Westminster	1	London Core
02AQ	Barking and Dagenham	48	Barking, Havering	1	London Core
02AR	Barnet	58	Barnet	1	London Core
02AS	Bexley	56	Bexley, Greenwich	1	London Core
02AT	Brent	60	Brent, Harrow	1	London Core
02AU	Bromley	55	Bromley	1	London Core
02AW	Croydon	53	Croydon	1	London Core
02AX	Ealing	62	Ealing, Hammersmith, Hounslow	1	London Core
02AY	Enfield	57	Enfield, Haringey	1	London Core
02AZ	Greenwich	56	Bexley, Greenwich	1	London Core
02BA	Harrow	60	Brent, Harrow	1	London Core
02BB	Havering	48	Barking, Havering	1	London Core
02BC	Hillingdon	59	Hillingdon	1	London Core
02BD	Hounslow	62	Ealing, Hammersmith, Hounslow	1	London Core
02BE	Kingston upon Thames	51	Richmond, Kingston	1	London Core
02BF	Merton	52	Merton, Sutton, Wandsworth	1	London Core
02BG	Redbridge	47	Redbridge, Waltham Forest	1	London Core
02BH	Richmond Upon Thames	51	Richmond, Kingston	1	London Core
02BJ	Sutton	52	Merton, Sutton, Wandsworth	1	London Core
02BK	Waltham Forest	47	Redbridge, Waltham Forest	1	London Core
03BL	Bolton	93	Bolton	13	Manchester Rest
03BM	Bury	94	Bury	13	Manchester Rest
03BN	Manchester	95	Manchester	12	Manchester Core
03BP	Oldham	96	Oldham	13	Manchester Rest
03BQ	Rochdale	97	Rochdale	13	Manchester Rest
03BR	Salford	98	Salford	13	Manchester Rest
03BS	Stockport	99	Stockport	13	Manchester Rest
03BT	Tameside	100	Tameside	13	Manchester Rest
03BU	Trafford	101	Trafford	13	Manchester Rest
03BW	Wigan	102	Wigan	13	Manchester Rest
04BX	Knowsley	104	St.Helens, Knowsley	17	Liverpool Rest
04BY	Liverpool	103	Liverpool	16	Liverpool Core
04BZ	St. Helens	104	St.Helens, Knowsley	17	Liverpool Rest
04CA	Sefton	105	Sefton	17	Liverpool Rest
04CB	Wirral	106	Wirral	17	Liverpool Rest
05CC	Barnsley	27	Barnsley	25	Sheffield Rest
05CE	Doncaster	28	Doncaster	25	Sheffield Rest
05CF	Rotherham	29	Rotherham	25	Sheffield Rest
05CG	Sheffield	30	Sheffield	24	Sheffield Core
06CH	Gateshead	18	Gateshead	29	Newcastle Rest
06CJ	Newcastle upon Tyne	19	Newcastle upon Tyne	28	Newcastle Core
06CK	North Tyneside	20	North Tyneside	29	Newcastle Rest
06CL	South Tyneside	21	South Tyneside	29	Newcastle Rest
06CM	Sunderland	22	Sunderland	29	Newcastle Rest

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
07CN	Birmingham	82	Birmingham	8	Birmingham Core
07CQ	Coventry	83	Coventry	9	Birmingham Rest
07CR	Dudley	84	Dudley	9	Birmingham Rest
07CS	Sandwell	85	Sandwell	9	Birmingham Rest
07CT	Solihull	86	Solihull	9	Birmingham Rest
07CU	Walsall	87	Walsall	9	Birmingham Rest
07CW	Wolverhampton	88	Wolverhampton	9	Birmingham Rest
08CX	Bradford	31	Bradford	21	Leeds Rest
08CY	Calderdale	32	Calderdale	21	Leeds Rest
08CZ	Kirklees	33	Kirklees	21	Leeds Rest
08DA	Leeds	34	Leeds	20	Leeds Core
08DB	Wakefield	35	Wakefield	21	Leeds Rest
09DC	Bath	75	Avon	5	Bristol Core
09DD	Bristol	75	Avon	5	Bristol Core
09DE	Kingswood	75	Avon	5	Bristol Core
09DF	Northavon	75	Avon	5	Bristol Core
09DG	Wansdyke	75	Avon	5	Bristol Core
09DH	Woodspring	75	Avon	5	Bristol Core
10DJ	Luton	63	Bedfordshire	3	London Near
10DK	Mid Bedfordshire	63	Bedfordshire	3	London Near
10DL	North Bedfordshire	63	Bedfordshire	3	London Near
10DM	South Bedfordshire	63	Bedfordshire	3	London Near
11DN	Bracknell Forest	67	Berkshire	2	London Rest
11DP	Newbury	67	Berkshire	2	London Rest
11DQ	Reading	67	Berkshire	2	London Rest
11DR	Slough	67	Berkshire	2	London Rest
11DS	Windsor and Maidenhead	67	Berkshire	2	London Rest
11DT	Wokingham	67	Berkshire	2	London Rest
12DU	Aylesbury Vale	64	Buckinghamshire	2	London Rest
12DW	Chiltern	64	Buckinghamshire	2	London Rest
12DX	Milton Keynes	64	Buckinghamshire	2	London Rest
12DY	South Buckinghamshire	64	Buckinghamshire	2	London Rest
12DZ	Wycombe	64	Buckinghamshire	2	London Rest
13EB	Cambridge	43	Cambridgeshire	3	London Near
13EC	East Cambridgeshire	43	Cambridgeshire	3	London Near
13EE	Fenland	43	Cambridgeshire	3	London Near
13EF	Huntingdonshire	43	Cambridgeshire	3	London Near
13EG	Peterborough	43	Cambridgeshire	3	London Near
13EH	South Cambridgeshire	43	Cambridgeshire	3	London Near
14EJ	Chester	107	Cheshire	14	Manchester Near
14EK	Congleton	107	Cheshire	14	Manchester Near
14EL	Crewe and Nantwich	107	Cheshire	14	Manchester Near
14EM	Ellesmere Port and Neston	107	Cheshire	14	Manchester Near
14EN	Halton	107	Cheshire	14	Manchester Near
14EP	Macclesfield	107	Cheshire	14	Manchester Near
14EQ	Vale Royal	107	Cheshire	14	Manchester Near
14ER	Warrington	107	Cheshire	14	Manchester Near
15ES	Hartlepool	23	Cleveland	30	Newcastle Near
15ET	Langbaurgh-on-Tees	23	Cleveland	30	Newcastle Near
15EU	Middlesbrough	23	Cleveland	30	Newcastle Near
15EW	Stockton-on-Tees	23	Cleveland	30	Newcastle Near
16EX	Caradon	76	Cornwall	7	Bristol Far
16EY	Carrick	76	Cornwall	7	Bristol Far
16EZ	Kerrier	76	Cornwall	7	Bristol Far
16FA	North Cornwall	76	Cornwall	7	Bristol Far
16FB	Penwith	76	Cornwall	7	Bristol Far
16FC	Restormel	76	Cornwall	7	Bristol Far
16FD	Isles of Scilly	76	Cornwall	7	Bristol Far
17FE	Allerdale	24	Cumbria	15	Manchester Far
17FF	Barrow-in-Furness	24	Cumbria	15	Manchester Far
17FG	Carlisle	24	Cumbria	15	Manchester Far
17FH	Copeland	24	Cumbria	15	Manchester Far
17FJ	Eden	24	Cumbria	15	Manchester Far
17FK	South Lakeland	24	Cumbria	15	Manchester Far

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
18FL	Amber Valley	38	Derbyshire	26	Sheffield Near
18FM	Bolsover	38	Derbyshire	26	Sheffield Near
18FN	Chesterfield	38	Derbyshire	26	Sheffield Near
18FP	Derby	38	Derbyshire	26	Sheffield Near
18FQ	Derbyshire Dales	38	Derbyshire	26	Sheffield Near
18FR	Erewash	38	Derbyshire	26	Sheffield Near
18FS	High Peak	38	Derbyshire	26	Sheffield Near
18FT	North East Derbyshire	38	Derbyshire	26	Sheffield Near
18FU	South Derbyshire	38	Derbyshire	26	Sheffield Near
19FW	East Devon	77	Devon	7	Bristol Far
19FX	Exeter	77	Devon	7	Bristol Far
19FY	Mid Devon	77	Devon	7	Bristol Far
19FZ	North Devon	77	Devon	7	Bristol Far
19GA	Plymouth	77	Devon	7	Bristol Far
19GB	South Hams	77	Devon	7	Bristol Far
19GC	Teignbridge	77	Devon	7	Bristol Far
19GD	Torbay	77	Devon	7	Bristol Far
19GE	Torridge	77	Devon	7	Bristol Far
19GF	West Devon	77	Devon	7	Bristol Far
20GG	Bournemouth	78	Dorset	7	Bristol Far
20GH	Christchurch	78	Dorset	7	Bristol Far
20GJ	East Dorset	78	Dorset	7	Bristol Far
20GK	North Dorset	78	Dorset	7	Bristol Far
20GL	Poole	78	Dorset	7	Bristol Far
20GM	Purbeck	78	Dorset	7	Bristol Far
20GN	West Dorset	78	Dorset	7	Bristol Far
20GP	Weymouth and Portland	78	Dorset	7	Bristol Far
21GQ	Chester-le-Street	25	Durham	30	Newcastle Near
21GR	Darlington	25	Durham	30	Newcastle Near
21GS	Derwentside	25	Durham	30	Newcastle Near
21GT	Durham	25	Durham	30	Newcastle Near
21GU	Easington	25	Durham	30	Newcastle Near
21GW	Sedgefield	25	Durham	30	Newcastle Near
21GX	Teesdale	25	Durham	30	Newcastle Near
21GY	Wear Valley	25	Durham	30	Newcastle Near
22GZ	Brighton	68	East Sussex	3	London Near
22HA	Eastbourne	68	East Sussex	3	London Near
22HB	Hastings	68	East Sussex	3	London Near
22HC	Hove	68	East Sussex	3	London Near
22HD	Lewes	68	East Sussex	3	London Near
22HE	Rother	68	East Sussex	3	London Near
22HF	Wealden	68	East Sussex	3	London Near
23HG	Basildon	65	Essex	2	London Rest
23HH	Braintree	65	Essex	2	London Rest
23HJ	Brentwood	65	Essex	2	London Rest
23HK	Castle Point	65	Essex	2	London Rest
23HL	Chelmsford	65	Essex	2	London Rest
23HM	Colchester	65	Essex	2	London Rest
23HN	Epping Forest	65	Essex	2	London Rest
23HP	Harlow	65	Essex	2	London Rest
23HQ	Maldon	65	Essex	2	London Rest
23HR	Rochford	65	Essex	2	London Rest
23HS	Southend-on-Sea	65	Essex	2	London Rest
23HT	Tendring	65	Essex	2	London Rest
23HU	Thurrock	65	Essex	2	London Rest
23HW	Uttlesford	65	Essex	2	London Rest
24HX	Cheltenham	79	Gloucestershire	6	Bristol Near
24HY	Cotswold	79	Gloucestershire	6	Bristol Near
24HZ	Forest of Dean	79	Gloucestershire	6	Bristol Near
24JA	Gloucester	79	Gloucestershire	6	Bristol Near
24JB	Stroud	79	Gloucestershire	6	Bristol Near
24JC	Tewkesbury	79	Gloucestershire	6	Bristol Near
25JD	Basingstoke and Deane	69	Hampshire	3	London Near
25JE	East Hampshire	69	Hampshire	3	London Near

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
25JF	Eastleigh	69	Hampshire	3	London Near
25JG	Fareham	69	Hampshire	3	London Near
25JH	Gosport	69	Hampshire	3	London Near
25JJ	Hart	69	Hampshire	3	London Near
25JK	Havant	69	Hampshire	3	London Near
25JL	New Forest	69	Hampshire	3	London Near
25JM	Portsmouth	69	Hampshire	3	London Near
25JN	Rushmoor	69	Hampshire	3	London Near
25JP	Southampton	69	Hampshire	3	London Near
25JQ	Test Valley	69	Hampshire	3	London Near
25JR	Winchester	69	Hampshire	3	London Near
26JS	Bromsgrove	89	Hereford and Worcester	10	Birmingham Near
26JT	Hereford	89	Hereford and Worcester	10	Birmingham Near
26JU	Leominster	89	Hereford and Worcester	10	Birmingham Near
26JW	Malvern Hills	89	Hereford and Worcester	10	Birmingham Near
26JX	Redditch	89	Hereford and Worcester	10	Birmingham Near
26JY	South Herefordshire	89	Hereford and Worcester	10	Birmingham Near
26JZ	Worcester	89	Hereford and Worcester	10	Birmingham Near
26KA	Wychavon	89	Hereford and Worcester	10	Birmingham Near
26KB	Wyre Forest	89	Hereford and Worcester	10	Birmingham Near
27KC	Broxbourne	66	Hertfordshire	2	London Rest
27KD	Dacorum	66	Hertfordshire	2	London Rest
27KE	East Hertfordshire	66	Hertfordshire	2	London Rest
27KF	Hertsmere	66	Hertfordshire	2	London Rest
27KG	North Hertfordshire	66	Hertfordshire	2	London Rest
27KH	St.Albans	66	Hertfordshire	2	London Rest
27KJ	Stevenage	66	Hertfordshire	2	London Rest
27KK	Three Rivers	66	Hertfordshire	2	London Rest
27KL	Watford	66	Hertfordshire	2	London Rest
27KM	Welwyn Hatfield	66	Hertfordshire	2	London Rest
28KN	Boothferry	36	Humberside	23	Leeds Far
28KP	Cleethorpes	36	Humberside	23	Leeds Far
28KQ	East Yorkshire	36	Humberside	23	Leeds Far
28KR	East Yorks. Borough of Beverley	36	Humberside	23	Leeds Far
28KS	Glanford	36	Humberside	23	Leeds Far
28KT	Great Grimsby	36	Humberside	23	Leeds Far
28KU	Holderness	36	Humberside	23	Leeds Far
28KW	Kingston Upon Hull	36	Humberside	23	Leeds Far
28KX	Scunthorpe	36	Humberside	23	Leeds Far
29KY	Medina	70	Isle of Wight	3	London Near
29KZ	South Wight	70	Isle of Wight	3	London Near
30LC	Ashford	71	Kent	2	London Rest
30LD	Canterbury	71	Kent	2	London Rest
30LE	Dartford	71	Kent	2	London Rest
30LF	Dover	71	Kent	2	London Rest
30LG	Gillingham	71	Kent	2	London Rest
30LH	Gravesham	71	Kent	2	London Rest
30LJ	Maidstone	71	Kent	2	London Rest
30LK	Rochester upon Medway	71	Kent	2	London Rest
30LL	Sevenoaks	71	Kent	2	London Rest
30LM	Shepway	71	Kent	2	London Rest
30LN	Swale	71	Kent	2	London Rest
30LP	Thanet	71	Kent	2	London Rest
30LQ	Tonbridge and Malling	71	Kent	2	London Rest
30LR	Tunbridge Wells	71	Kent	2	London Rest
31LS	Blackburn	108	Lancashire	14	Manchester Near
31LT	Blackpool	108	Lancashire	14	Manchester Near
31LU	Burnley	108	Lancashire	14	Manchester Near
31LW	Chorley	108	Lancashire	14	Manchester Near
31LX	Fylde	108	Lancashire	14	Manchester Near
31LY	Hyndburn	108	Lancashire	14	Manchester Near
31LZ	Lancaster	108	Lancashire	14	Manchester Near
31MA	Pendle	108	Lancashire	14	Manchester Near
31MB	Preston	108	Lancashire	14	Manchester Near

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
31MC	Ribble Valley	108	Lancashire	14	Manchester Near
31MD	Rossendale	108	Lancashire	14	Manchester Near
31ME	South Ribble	108	Lancashire	14	Manchester Near
31MF	West Lancashire	108	Lancashire	14	Manchester Near
31MG	Wyre	108	Lancashire	14	Manchester Near
32MH	Blaby	39	Leicestershire	26	Sheffield Near
32MJ	Charnwood	39	Leicestershire	26	Sheffield Near
32MK	Harborough	39	Leicestershire	26	Sheffield Near
32ML	Hinckley and Bosworth	39	Leicestershire	26	Sheffield Near
32MM	Leicester	39	Leicestershire	26	Sheffield Near
32MN	Melton	39	Leicestershire	26	Sheffield Near
32MP	North West Leicestershire	39	Leicestershire	26	Sheffield Near
32MQ	Oadby and Wigston	39	Leicestershire	26	Sheffield Near
32MR	Rutland	39	Leicestershire	26	Sheffield Near
33MS	Boston	40	Lincolnshire	26	Sheffield Far
33MT	East Lindsey	40	Lincolnshire	27	Sheffield Far
33MU	Lincoln	40	Lincolnshire	27	Sheffield Far
33MW	North Kesteven	40	Lincolnshire	27	Sheffield Far
33MX	South Holland	40	Lincolnshire	27	Sheffield Far
33MY	South Kesteven	40	Lincolnshire	27	Sheffield Far
33MZ	West Lindsey	40	Lincolnshire	27	Sheffield Far
34NA	Breckland	44	Norfolk	4	London Far
34NB	Broadland	44	Norfolk	4	London Far
34NC	Great Yarmouth	44	Norfolk	4	London Far
34ND	King's Lynn and West Norfolk	44	Norfolk	4	London Far
34NE	North Norfolk	44	Norfolk	4	London Far
34NF	Norwich	44	Norfolk	4	London Far
34NG	South Norfolk	44	Norfolk	4	London Far
35NH	Corby	41	Northamptonshire	3	London Near
35NJ	Daventry	41	Northamptonshire	3	London Near
35NK	East Northamptonshire	41	Northamptonshire	3	London Near
35NL	Kettering	41	Northamptonshire	3	London Near
35NM	Northampton	41	Northamptonshire	3	London Near
35NN	South Northamptonshire	41	Northamptonshire	3	London Near
35NP	Wellingborough	41	Northamptonshire	3	London Near
36NQ	Alnwick	26	Northumberland	30	Newcastle Near
36NR	Berwick-upon-Tweed	26	Northumberland	30	Newcastle Near
36NS	Blyth Valley	26	Northumberland	30	Newcastle Near
36NT	Castle Morpeth	26	Northumberland	30	Newcastle Near
36NU	Tynedale	26	Northumberland	30	Newcastle Near
36NW	Wansbeck	26	Northumberland	30	Newcastle Near
37NX	Craven	37	North Yorkshire	22	Leeds Near
37NY	Hambleton	37	North Yorkshire	22	Leeds Near
37NZ	Harrogate	37	North Yorkshire	22	Leeds Near
37PA	Richmondshire	37	North Yorkshire	22	Leeds Near
37PB	Ryedale	37	North Yorkshire	22	Leeds Near
37PC	Scarborough	37	North Yorkshire	22	Leeds Near
37PD	Selby	37	North Yorkshire	22	Leeds Near
37PE	York	37	North Yorkshire	22	Leeds Near
38PF	Ashfield	42	Nottinghamshire	26	Sheffield Near
38PG	Bassetlaw	42	Nottinghamshire	26	Sheffield Near
38PH	Broxtowe	42	Nottinghamshire	26	Sheffield Near
38PJ	Gedling	42	Nottinghamshire	26	Sheffield Near
38PK	Mansfield	42	Nottinghamshire	26	Sheffield Near
38PL	Newark and Sherwood	42	Nottinghamshire	26	Sheffield Near
38PM	Nottingham	42	Nottinghamshire	26	Sheffield Near
38PN	Rushcliffe	42	Nottinghamshire	26	Sheffield Near
39PP	Cherwell	72	Oxfordshire	3	London Near
39PQ	Oxford	72	Oxfordshire	3	London Near
39PR	South Oxfordshire	72	Oxfordshire	3	London Near
39PS	Vale of White Horse	72	Oxfordshire	3	London Near
39PT	West Oxfordshire	72	Oxfordshire	3	London Near
40PU	Bridgnorth	90	Shropshire	10	Birmingham Near
40PW	North Shropshire	90	Shropshire	10	Birmingham Near

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
40PX	Oswestry	90	Shropshire	10	Birmingham Near
40PY	Shrewsbury and Atcham	90	Shropshire	10	Birmingham Near
40PZ	South Shropshire	90	Shropshire	10	Birmingham Near
40QA	The Wrekin	90	Shropshire	10	Birmingham Near
41QB	Mendip	80	Somerset	6	Bristol Near
41QC	Sedgemoor	80	Somerset	6	Bristol Near
41QD	South Somerset	80	Somerset	6	Bristol Near
41QE	Taunton Deane	80	Somerset	6	Bristol Near
41QF	West Somerset	80	Somerset	6	Bristol Near
42QG	Cannock Chase	91	Staffordshire	10	Birmingham Near
42QH	East Staffordshire	91	Staffordshire	10	Birmingham Near
42QJ	Lichfield	91	Staffordshire	10	Birmingham Near
42QK	Newcastle-under-Lyme	91	Staffordshire	10	Birmingham Near
42QL	South Staffordshire	91	Staffordshire	10	Birmingham Near
42QM	Stafford	91	Staffordshire	10	Birmingham Near
42QN	Staffordshire Moorlands	91	Staffordshire	10	Birmingham Near
42QP	Stoke-on-Trent	91	Staffordshire	10	Birmingham Near
42QQ	Tamworth	91	Staffordshire	10	Birmingham Near
43QR	Babergh	45	Suffolk	3	London Near
43QS	Forest Heath	45	Suffolk	3	London Near
43QT	Ipswich	45	Suffolk	3	London Near
43QU	Mid Suffolk	45	Suffolk	3	London Near
43QW	St.Edmundsbury	45	Suffolk	3	London Near
43QX	Suffolk Coastal	45	Suffolk	3	London Near
43QY	Waveney	45	Suffolk	3	London Near
44QZ	Elmbridge	73	Surrey	2	London Rest
44RA	Epsom and Ewell	73	Surrey	2	London Rest
44RB	Guildford	73	Surrey	2	London Rest
44RC	Mole Valley	73	Surrey	2	London Rest
44RD	Reigate and Banstead	73	Surrey	2	London Rest
44RE	Runnymede	73	Surrey	2	London Rest
44RF	Spelthorne	73	Surrey	2	London Rest
44RG	Surrey Heath	73	Surrey	2	London Rest
44RH	Tandridge	73	Surrey	2	London Rest
44RJ	Waverley	73	Surrey	2	London Rest
44RK	Woking	73	Surrey	2	London Rest
45RL	North Warwickshire	92	Warwickshire	10	Birmingham Rest
45RM	Nuneaton and Bedworth	92	Warwickshire	10	Birmingham Near
45RN	Rugby	92	Warwickshire	10	Birmingham Near
45RP	Stratford-on-Avon	92	Warwickshire	10	Birmingham Near
45RQ	Warwick	92	Warwickshire	10	Birmingham Near
46RR	Adur	74	West Sussex	3	London Near
46RS	Arun	74	West Sussex	3	London Near
46RT	Chichester	74	West Sussex	3	London Near
46RU	Crawley	74	West Sussex	3	London Near
46RW	Horsham	74	West Sussex	3	London Near
46RX	Mid Sussex	74	West Sussex	3	London Near
46RY	Worthing	74	West Sussex	3	London Near
47RZ	Kennet	81	Wiltshire	6	Bristol Near
47SA	North Wiltshire	81	Wiltshire	6	Bristol Near
47SB	Salisbury	81	Wiltshire	6	Bristol Near
47SC	Thamesdown	81	Wiltshire	6	Bristol Near
47SD	West Wiltshire	81	Wiltshire	6	Bristol Near
48SE	Alyn and Deeside	109	Clwyd	18	Liverpool Near
48SF	Colwyn	109	Clwyd	18	Liverpool Near
48SG	Delyn	109	Clwyd	18	Liverpool Near
48SH	Glyndwr	109	Clwyd	18	Liverpool Near
48SJ	Rhuddlan	109	Clwyd	18	Liverpool Near
48SK	Wrexham Maelor	109	Clwyd	18	Liverpool Near
49SL	Carmarthen	110	Dyfed	18	Liverpool Near
49SM	Ceredigion	110	Dyfed	33	Cardiff Far
49SN	Dinefwr	110	Dyfed	33	Cardiff Far
49SP	Llanelli	110	Dyfed	33	Cardiff Far
49SQ	Preseli Pembrokeshire	110	Dyfed	33	Cardiff Far

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
49SR	South Pembrokeshire	110	Dyfed	33	Cardiff Far
50SS	Blaenau Gwent	111	Gwent	33	Cardiff Far
50ST	Islwyn	111	Gwent	32	Cardiff Near
50SU	Monmouth	111	Gwent	32	Cardiff Near
50SW	Newport	111	Gwent	32	Cardiff Near
50SX	Torfaen	111	Gwent	32	Cardiff Near
51SY	Aberconwy	112	Gwynedd	32	Cardiff Near
51SZ	Arfon	112	Gwynedd	19	Liverpool Far
51TA	Dwyfor	112	Gwynedd	19	Liverpool Far
51TB	Meirionnydd	112	Gwynedd	19	Liverpool Far
51TC	Ynys Mon-Isle of Anglesey	112	Gwynedd	19	Liverpool Far
52TD	Cynon Valley	113	Mid Glamorgan	19	Liverpool Far
52TE	Merthyr Tydfil	113	Mid Glamorgan	32	Cardiff Near
52TF	Ogwr	113	Mid Glamorgan	32	Cardiff Near
52TG	Rhondda	113	Mid Glamorgan	32	Cardiff Near
52TH	Rhymney Valley	113	Mid Glamorgan	32	Cardiff Near
52TJ	Taff-Ely	113	Mid Glamorgan	32	Cardiff Near
53TK	Brecknock	114	Powys	32	Cardiff Near
53TL	Montgomeryshire	114	Powys	11	Birmingham Far
53TM	Radnor	114	Powys	11	Birmingham Far
54TN	Cardiff	115	South Glamorgan	11	Birmingham Far
54TP	Vale of Glamorgan	115	South Glamorgan	31	Cardiff Core
55TQ	Lliw Valley	116	West Glamorgan	31	Cardiff Core
55TR	Neath	116	West Glamorgan	32	Cardiff Near
55TS	Port Talbot	116	West Glamorgan	32	Cardiff Near
55TT	Swansea	116	West Glamorgan	32	Cardiff Near
5601	Berwickshire	3	Border	32	Cardiff Near
5602	Ettrick and Lauderdale	3	Border	34	Scotland
5603	Roxburgh	3	Border	34	Scotland
5604	Tweeddale	3	Border	34	Scotland
5705	Clackmannan	13	Forth Valley	34	Scotland
5706	Falkirk	13	Forth Valley	34	Scotland
5707	Stirling	13	Forth Valley	34	Scotland
5808	Annandale and Eskdale	15	Dumfries and Galloway	34	Scotland
5809	Nithsdale	15	Dumfries and Galloway	34	Scotland
5810	Stewarty	15	Dumfries and Galloway	34	Scotland
5811	Wigtown	15	Dumfries and Galloway	34	Scotland
5912	Dunfermline	5	Fife	34	Scotland
5913	Kirkcaldy	5	Fife	34	Scotland
5914	North East Fife	5	Fife	34	Scotland
6015	Aberdeen City	9	Grampian	34	Scotland
6016	Banff and Buchan	9	Grampian	34	Scotland
6017	Gordon	9	Grampian	34	Scotland
6018	Kincardine and Deeside	9	Grampian	34	Scotland
6019	Moray	9	Grampian	34	Scotland
6120	Badenoch and Strathspey	7	Highland	34	Scotland
6121	Caithness	7	Highland	34	Scotland
6122	Inverness	7	Highland	34	Scotland
6123	Lochaber	7	Highland	34	Scotland
6124	Nairn	7	Highland	34	Scotland
6125	Ross and Cromarty	7	Highland	34	Scotland
6126	Skye and Lochalsh	7	Highland	34	Scotland
6127	Sutherland	7	Highland	34	Scotland
6228	East Lothian	11	Lothian	34	Scotland
6229	Edinburgh City	11	Lothian	34	Scotland
6230	Midlothian	11	Lothian	34	Scotland
6231	West Lothian	11	Lothian	34	Scotland
6332	Argyll and Bute	4	Argyll and Clyde	34	Scotland
6333	Bearsden and Milngavie	6	Greater Glasgow	34	Scotland
6334	Clydebank	6	Greater Glasgow	34	Scotland
6335	Cumbernauld and Kilsyth	8	Lanark	34	Scotland
6336	Cumnock and Doon Valley	2	Ayr and Arran	34	Scotland

Appendix 3 (Continued)

Census code	District name	TIMMIG FHSA order	FHSA name	New Region no.	New region name
6337	Cunninghame	2	Ayr and Arran	34	Scotland
6338	Dumbarton	4	Argyll and Clyde	34	Scotland
6339	East Kilbride	8	Lanark	34	Scotland
6340	Eastwood	6	Greater Glasgow	34	Scotland
6341	Glasgow City	6	Greater Glasgow	34	Scotland
6342	Hamilton	8	Lanark	34	Scotland
6343	Inverclyde	4	Argyll and Clyde	34	Scotland
6344	Kilmarnock and Loudon	2	Ayr and Arran	34	Scotland
6345	Kyle and Carrick	2	Ayr and Arran	34	Scotland
6346	Clydesdale	8	Lanark	34	Scotland
6347	Monklands	8	Lanark	34	Scotland
6348	Motherwell	8	Lanark	34	Scotland
6349	Renfrew	4	Argyll and Clyde	34	Scotland
6350	Strathkelvin	6	Greater Glasgow	34	Scotland
6451	Angus	12	Tayside	34	Scotland
6452	Dundee City	12	Tayside	34	Scotland
6453	Perth and Kinross	12	Tayside	34	Scotland
6554	Orkney	10	Orkney	34	Scotland
6655	Shetland	16	Shetland	34	Scotland
6756	Western Isles	14	Western Isles	34	Scotland

Look-up table from AHBs to APC zones

TMIG order	FHSA code	FHSA name	APC Code	TMIG order	FHSA code	FHSA name	APC Code
1	026	Northern Ireland	1	63	245	Bedfordshire	43
2	027	Ayr and Arran	2	64	250	Buckinghamshire	44
3	028	Border	2	65	255	Essex	45
4	029	Argyll and Clyde	2	66	260	Hertfordshire	46
5	030	Fife	2	67	265	Berkshire	47
6	031	Greater Glasgow	2	68	270	East Sussex	48
7	032	Highland	2	69	275	Hampshire	49
8	033	Lanark	2	70	280	Isle Of Wight	50
9	034	Grampian	2	71	285	Kent	51
10	035	Orkney	2	72	290	Oxfordshire	52
11	036	Lothian	2	73	295	Surrey	53
12	037	Tayside	2	74	300	West Sussex	54
13	038	Forth Valley	2	75	305	Avon	55
14	039	Western Isles	2	76	310	Cornwall	56
15	040	Dumfries and Galloway	2	77	315	Devon	57
16	041	Shetland	2	78	320	Dorset	58
17	042	Scotland (general/n.f.s)	2	79	325	Gloucestershire	59
18	043	Gateshead	3	80	330	Somerset	60
19	045	Newcastle	4	81	335	Wiltshire	61
20	055	North Tyneside	5	82	340	Birmingham	62
21	060	South Tyneside	6	83	345	Coventry	63
22	065	Sunderland	7	84	350	Dudley	64
23	070	Cleveland	8	85	355	Sandwell	65
24	075	Cumbria	9	86	360	Solihull	66
25	080	Durham	10	87	365	Walsall	67
26	085	Northumberland	11	88	370	Wolverhampton	68
27	090	Barnsley	12	89	375	Hereford and Worcester	69
28	095	Doncaster	13	90	380	Shropshire	70
29	100	Rotherham	14	91	385	Staffordshire	71
30	105	Sheffield	15	92	390	Warwickshire	72
31	110	Bradford	16	93	395	Bolton	73
32	115	Calderdale	17	94	400	Bury	74
33	120	Kirklees	18	95	405	Manchester	75
34	125	Leeds	19	96	410	Oldham	76
35	130	Wakefield	20	97	415	Rochdale	77
36	135	Humberside	21	98	420	Salford	78
37	140	North Yorkshire	22	99	425	Stockport	79
38	145	Derbyshire	23	100	430	Tameside	80
39	150	Leicestershire	24	101	435	Trafford	81
40	155	Lincolnshire	25	102	440	Wigan	82
41	160	Northamptonshire	26	103	445	Liverpool	83
42	165	Nottinghamshire	27	104	450	St.Helens and Knowsley	84
43	170	Cambridgeshire	28	105	455	Sefton	85
44	175	Norfolk	29	106	460	Wirral	86
45	180	Suffolk	30	107	465	Cheshire	87
46	185	City, Hackney, Newham and Tower Hamlets	31	108	470	Lancashire	88
47	190	Redbridge and Waltham Forest	32	109	475	Clwyd	89
48	195	Barking and Havering	33	110	480	Dyfed	90
49	200	Camden and Islington	34	111	485	Gwent	91
50	205	Kensington & Chelsea and Westminster	35	112	490	Gwynedd	92
51	210	Richmond and Kingston	36	113	495	Mid Glamorgan	93
52	215	Merton & Sutton and Wandsworth	37	114	500	Powys	94
53	220	Croydon	38	115	505	South Glamorgan	95
54	225	Lambeth, Southwark and Lewishm	39	116	510	West Glamorgan	96
55	230	Bromley	40	117		Not Stated	
56	235	Bexley and Greenwich	41				
57	236	Enfield and Haringey	42				
58	237	Barnet	42				
59	238	Hillingdon	42				
60	239	Brent and Harrow	42				
61	240	Middlesex Not Stated	42				
62	241	Ealing, Hammersmith and Hounslow	42				

Notes: 1. TMIG = TIMMIG = TIMe Series of MIGration data system is described in Duke-Williams and Rees 1993.
2. APC code 2 = Scotland; APC code 42 = Middlesex