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Developing Strategies for Deriving Small Population Migration Rates

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This working paper is intended as a resource for users intending to create small area and/or ethnic group migration rates. It presents methods, data and various strategies for creating migration rates for use in population projections and introduces the ways of modelling migration rates. It also presents examples using data from the Bradford district and outlines data sources that could be used to assist in the creation of migration rates for Bradford wards and/or ethnic groups (including country of birth (COB)). While no ethnic-specific age-specific migration rates (ASMigRs) are created, a pragmatic strategy is presented at the Bradford ward-level.
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Summary

This working paper is intended as a resource for users intending to create small area and/or ethnic group migration rates. It presents methods, data and various strategies for creating migration rates for use in population projections. The working paper introduces the ways of modelling migration rates. The working paper presents examples using data from the Bradford district and outlines data sources that could be used to assist in the creation of migration rates for Bradford wards and/or ethnic groups (including country of birth (COB)). While no ethnic-specific age-specific migration rates (ASMigRs) are created, a pragmatic strategy is presented at the Bradford ward-level.

Background information

The working paper originally formed part of the authors PhD research training as a review of methods and previous research on migration rates at the subnational-level and by ethnic group (and country of birth). A basic strategy is presented on how to deal with small area migration rates; however, there is no actual modelling/smoothing of migration rates.

The authors PhD was CASE (Co-operative Awards in Science and Engineering) sponsored by Bradford Metropolitan District Council (MDC) and therefore demographic rates were created for the thirty electoral wards within the Bradford district, with the aim that these would then be used in population projections.

1 Developing Strategies for Deriving Small Population Migration Rates

1.1 Introduction

The ultimate aims of this working paper are primarily to inform migration choices, by providing options of data that users, such as people working in Local Authorities (LAs) can utilise in population projections for small areas and/or ethnic groups. This working paper identifies possible data sources that could be used to estimate the migration component in population projections for Bradford. Where available, it gives data sources according to ethnic group. It also presents methods for modelling migration rates and provides examples of their application. However, no actual ethnic-specific, age-specific migration rates (ASMigRs) are directly estimated; although a pragmatic strategy of indirectly accounting for migration at the ward-level is presented.

Unlike fertility and mortality components in creating population projections, there is a complexity in what exactly constitutes being a migrant and why people migrate. In reviewing the literature on migration, it would have been very easy to get involved in all the reasons as to why people migrate and to address what constitutes someone being a migrant. At the outset of the working paper, it is stated that all aspects of migration will not be covered, as this is not the focus of this research. The focus here is primarily concerned with the 'stocks and flows' of people and not critically engaging with all the theories that lie behind the events that constitute migration. Bell *et al* (2002, 2003) describe the measures of migration; the main two are events and transitions:

> Migration can be measured in a number of ways with the two most common forms being *events* and *transitions*. The former are normally associated with population registers which record individual moves while the latter generally derive from Censuses which compare place of residence at two discrete points in time (Bell *et al*. 2003:8)

There is an acknowledgment of the difficulty in how to define a migrant - compared with defining or counting a birth and death to create a fertility or mortality rate - since there can debate over what exactly constitutes a move. For the purpose of this investigation, migration is defined, or limited, primarily by how the migration event is captured in the data source. To given an example, if using the Census data, there is a question in the Census that records all the people who have moved in the last year, thus using the Census data the people who are recorded as moving will be the migrants.

1.2 Migration data sources for creating population statistics

The main migration data sources used for creating estimates and population projections for the general population of England at the national-level and subnational-level were presented in Chapter 3 of the author's PhD research (Williamson 2006), however, the focus of this working paper is on small areas, in particular the Bradford wards, and also for ethnic groups. This section introduces the main data sources that can be used to account for migration in these population groups. For each source, the suitability of its use for creating small area/group population statistics is considered. The main data sources that can be used to capture migration for general populations are listed:

- Census
- NHSCR (National Health Service central registers)
- Electoral roll data

For each of the data sources, wherever possible, examples will be given of where the data has been used subnationally and for the Bradford district in particular. From the outset, ethnic group migration will not be fully addressed since ethnic group is seldom recorded the in data sources that could be used to capture migration. Often only country of birth or citizenship is recorded, for example, COB is recorded in the IPS and the port health notifications. In the ONS *Population projections by ethnic group a feasibility study*, edited by Haskey (2002) there are two chapters on migration 'Internal migration by ethnic group: data sources' by Anne Scott and Lucy Vickers and 'External migration and ethnic group' by John Salt. Both chapters go far beyond the amount of information that can be given in this working paper. Storkey (2002) also discusses potential data sources which could be used to account for migration by ethnic group with a particular focus on London. The potential sources identified for capturing migration for these groups by Scott and Vickers (2002:105-111), Salt (2002:94-97) and Storkey (2002:130-133) include:

- The Census
- National Health Service data
- The ONS Longitudinal Survey (LS)
- International Passenger Survey (IPS)
- Administrative data (such as electoral roll data)
- Sample surveys (such as the LFS)
- Home Office data on immigration control and settlement
- Adjustments to ONS migration data

Of which Salt (2002) points out that the IPS is the only source that records emigration and that only the Census and the LFS actually record ethnic group. A full description of each is not given here, only the first four are discussed; since the purpose of this section is to introduce the potential migration sources for small areas. Moreover, another source the port health notifications are described and examples of previous subnational research using these data sources are given where appropriate.

1.2.1 Census of population

The Census of population is one resource that can be used to identify migrants. The Census questionnaire is asked of the whole population and therefore it should be the most complete data source in the UK. The way in which migrants are identified is from the question on usual residence. The questions asks if the current address is the same as one year before the Census, if it different to the current address the person is classed as a migrant. There are many ways in which this question is used to provide data output. There are general counts of migrants from the Census output standard tables. There are other more detailed outputs available as part of the Census dissemination, including the specially commissioned tables, the Samples of Anonymised Records (SARs) and the Special Migration Statistics (SMS). Details of these are described below, including advice on how they could be operationalised to account for migration, in population projections.

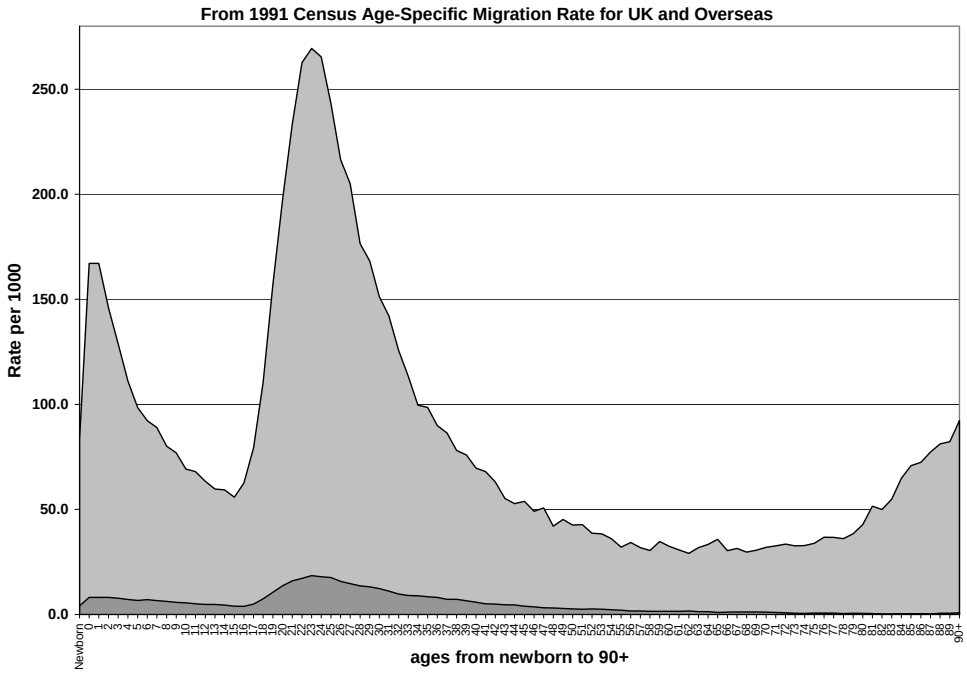
1.2.1.1 Samples of Anonymised Records (SARs)

The SARs are samples of anonymised Census records that are available under licence; these have been available from 1991. In 1991, there was individual and a household SAR file, accounting for 2% and 1% of the population respectively (CCSR 2005). The individual level SAR is of interest for population projections as it gives details of the population by age and sex across Census variables (from the Census form).

The way in which the SARs can be used in population projections was prepared by Simpson (2001) from the individual 2% SARs. Simpson created an age-specific migration rates (ASmigR) for general migration within Great Britain (GB) and a migration rate from overseas, using the 1991 Census. These are shown in figure 1 below and display accepted features of the migration curves, such as peaks at infant ages, labour market ages and for retirement (these are expanded in the methodologies section 1.3). From the chart, the within GB migration has migration for young ages,

labour market migration peaking around age 23 and evidence of post-retirement migrants. For the people who moved from overseas in the year before the Census there is only slight post-retirement migration (for ages 88+, which is not evident from the scale used in figure 1 below).

Figure 1 ASMR for migration within GB and in-migrants overseas (from 2001 individual SAR)



Source: Ludi Simpson (21-21-01) ASMigRs available in the Popgroup package Version 2
"ASMigR UK: The within-GB persons migration rate from the 1991 Census (ESRC 2% SARs) and ASMigR overseas: The persons migration rate to Britain from overseas from the 1991 Census (ESRC 2% SARs)."

In calculating the ASMigR, Simpson made some assumptions at the country-level, including setting the migration rates of newborns to that of 1-year olds. In addition, for in-migration from overseas, it was necessary to use an average of three-ages to produce smoother rates. While these modifications are reasonable faced with data problems, a further assumption was made, this was to assume the same migration experience for both males and females. This assumption may not be entirely reliable; however, again, with the lack of useful migration data, together with the time and data requirements to create the two separate migration rates by single year of age (SYOA), this assumption may be the most pragmatic.

In considering the SARs for creating ASMigRs for the Bradford district or by ethnic group (even without any subnational breakdown), it was decided not to pursue this data source. It is only a 2% sample of the population therefore the numbers involved

will be very small. Nevertheless, later in this chapter these national-level ASMigRs will used in an attempt to improved migration data for a Bradford ward-level projection.

1.2.1.2 Special Migration Statistics (SMS)

Another output from the 1991 Census dissemination is the special migration statistics (SMS). In 1991 there were two sets of SMS: one for wards and the other for districts by ethnic group. The SMS are stocks, or counts, of people's movements between wards (or postcode sectors for Scotland), for set 1 and districts for set 2 (Leeds University 2004).

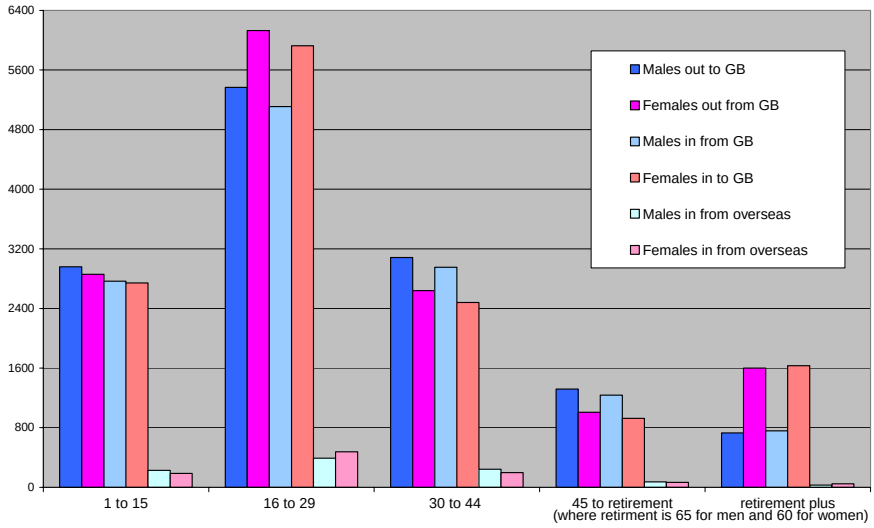
Presented in this section is data exploration using the 1991 SMS for the Bradford wards. This could easily be reproduced for any wards for either 1991 or 2001. Ludi Simpson (formerly of Bradford MDC) provided the data and calculations, although details of the calculations are given below[1]. The three migration flows created are:

1. migration rates out to Great Britain from the ward
2. migration rate in to the ward from Great Britain
3. migration rate to the ward from overseas

Shown in figure 2 are the counts of the migration stocks for these three migration flows for the Bradford district overall. The largest count of people moving either in or out of the Bradford district is for age group 16 to 29 for all flows. This is expected, these are the ages when people are more mobile, including when people are entering into the labour market.

[1] The 1991 SMS were originally made available to the researcher to assess the feasibility of their inclusion while performing sensitivity analysis of the Bradford ward-level population projections using in POPGROUP.

Figure 2 Chart of SMS by broad age groups for males and females in Bradford district (1991)

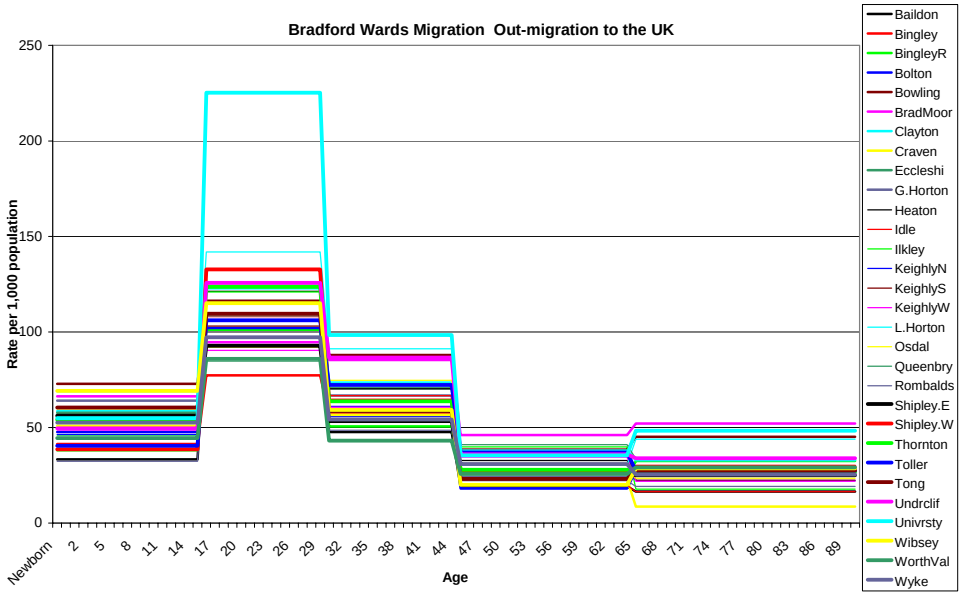


Source: 1991 SMS set 1, data provided by Ludi Simpson for Bradford ward-level projections

To further investigate the SMS the ASMigRs were investigated by ward, to see if there were any difference in the patterns of migration by the wards. In all cases the calculation is: rate = migrants / Census population of ward

Noting that in the calculation for in-migration the denominator is taken to be that of the receiving ward population. This is the most pragmatic option in practice, as suggested by Hinde (1998:193). Figure 3 below shows the male ASMigRs for out-migration to GB.

Figure 3 Migration rates from SMS 1991 out to Great Britain from the ward (males only)

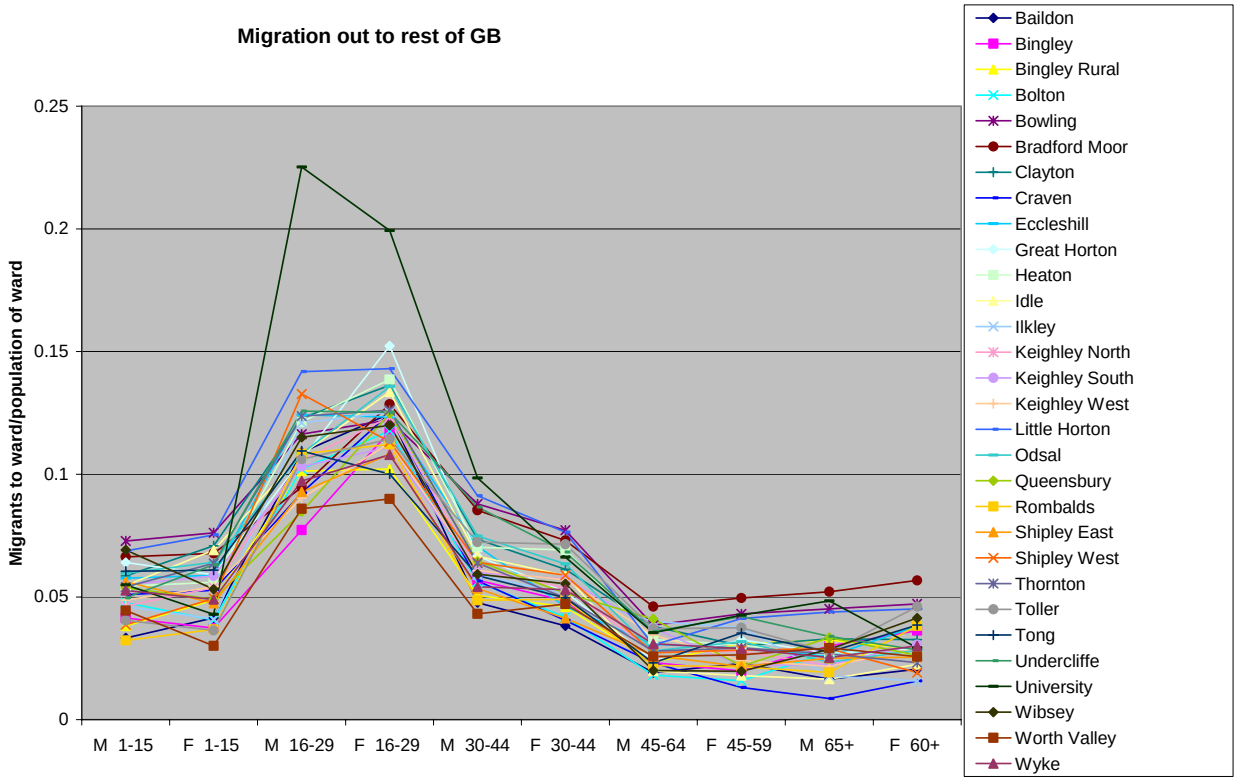


Source: 1991 SMS set 1, data provided by Ludi Simpson for Bradford ward-level projections

From figure 3 chart shown above it is noticeable that firstly, the migration schedule does not reflect the general shape of migration curves (such as figure 2 from using the 1991 SARs). This is owing to the fact that the SMS are only available in broad-banded age groups. Nevertheless, it does capture the high peak for younger labour market ages and for some retirement migration effects. The 1991 SMS are available in counts of people, by sex, are in broad age groups, these are: 1-15 year olds, 16-29 year olds, 30-44 year olds, 45-retirment age and then 65+ for males and 60+ for females (retirement ages). There is no rate for newborns, meaning there is an assumption made for this age group. The most straightforward option would be to use the rate for the 1-15year olds, or to use half of this rate - as proposed by Simpson (2001) in creating the ASMigRs from the 1991 SAR. Inspecting the graph above of the out-migration rates for males from Bradford wards identifies straight away that the rate of movement from the wards to the rest of Great Britain is not occurring at the same level for the age-groups. The highest rate is for the ward University for the ages 16-29, this point will be addressed in the next section.

Rather than exploring each of the three migration streams in turn for the sexes, and given that these are in broad age-groups, both sexes are included on the x-axis of the next three figures for comparison. Each migration stream is presented below for the thirty Bradford wards and observations discussed. Figure 4 is migration out to the rest of Great Britain from the Bradford wards (again the x-axis is broad age-groups for both sexes).

Figure 4 Migration rates from SMS out to Great Britain from the wards (1991)



Source: 1991 SMS set 1, data provided by Ludi Simpson for Bradford ward-level projections

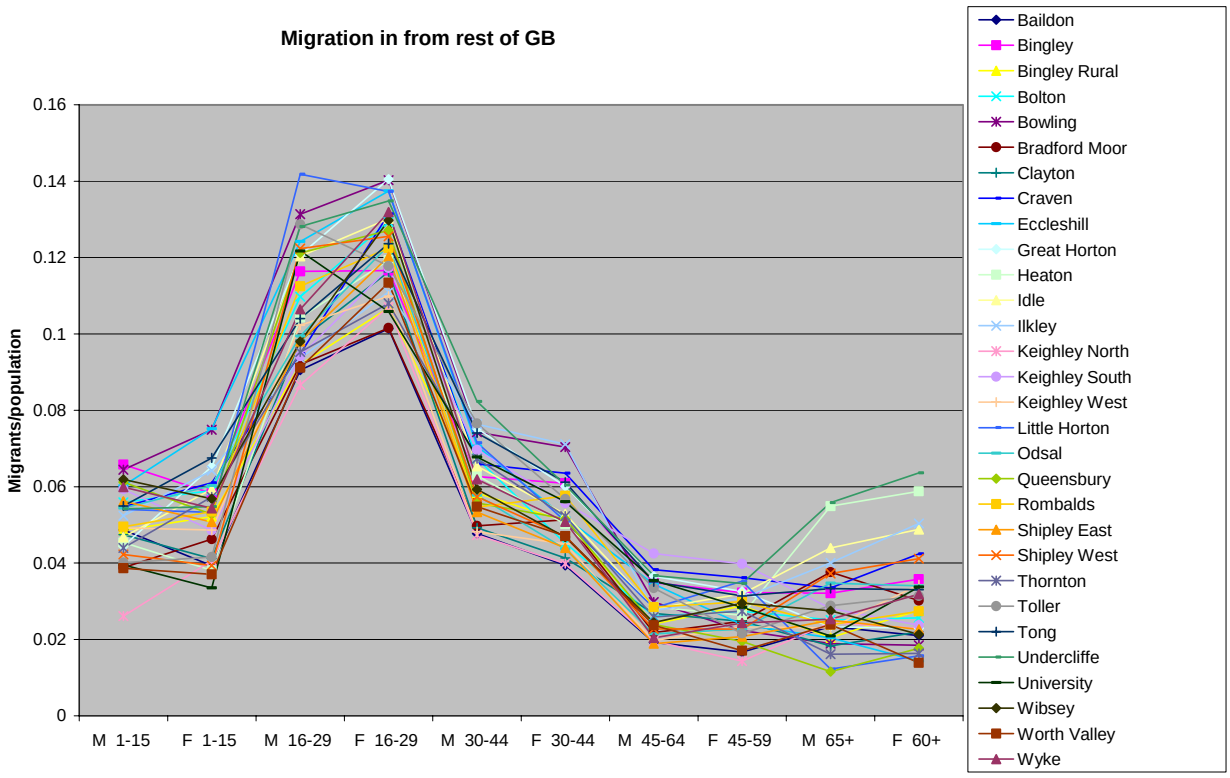
From the chart, as with the chart for males (figure 4), the highest out-migration, as defined by using the Census question, is for the ward University for the ages 16-29 years. This may be attributed to counting new students at their 'home' addresses and not their term address, whereas leaving/finishing students when asked where they lived one year previously would give their university term address. The effect is biasing the SMS to appear as if some wards, that are predominately student areas, are losing a higher proportion of their population than they truly are. This point was highlighted in detail by Simpson (1995) in a Local Authorities Research and Intelligence Association (LARIA) publication on *Using the SMS: Examining the ward migration and migrants' ethnic group* for Bradford, which gives examples that questions the reliability of the SMS for use in population projections.

Overall, with the notable exception of University, the levels of migration for males and females are not dramatically different. For University there is higher out migration for males at all ages, with the exception of the 45 to pre-retirement ages. Another ward, that from the chart has high rates, is Little Horton (shown in blue) an inner-city ward, which is generally high across all age groups for both sexes. The

ward with the highest retirement age out-migration rate is from the Bradford Moor ward (shown in burgundy).

Figure 5 shows the migration into the Bradford wards from Great Britain:

Figure 5 Migration rate from SMS in to the wards from Great Britain (1991)

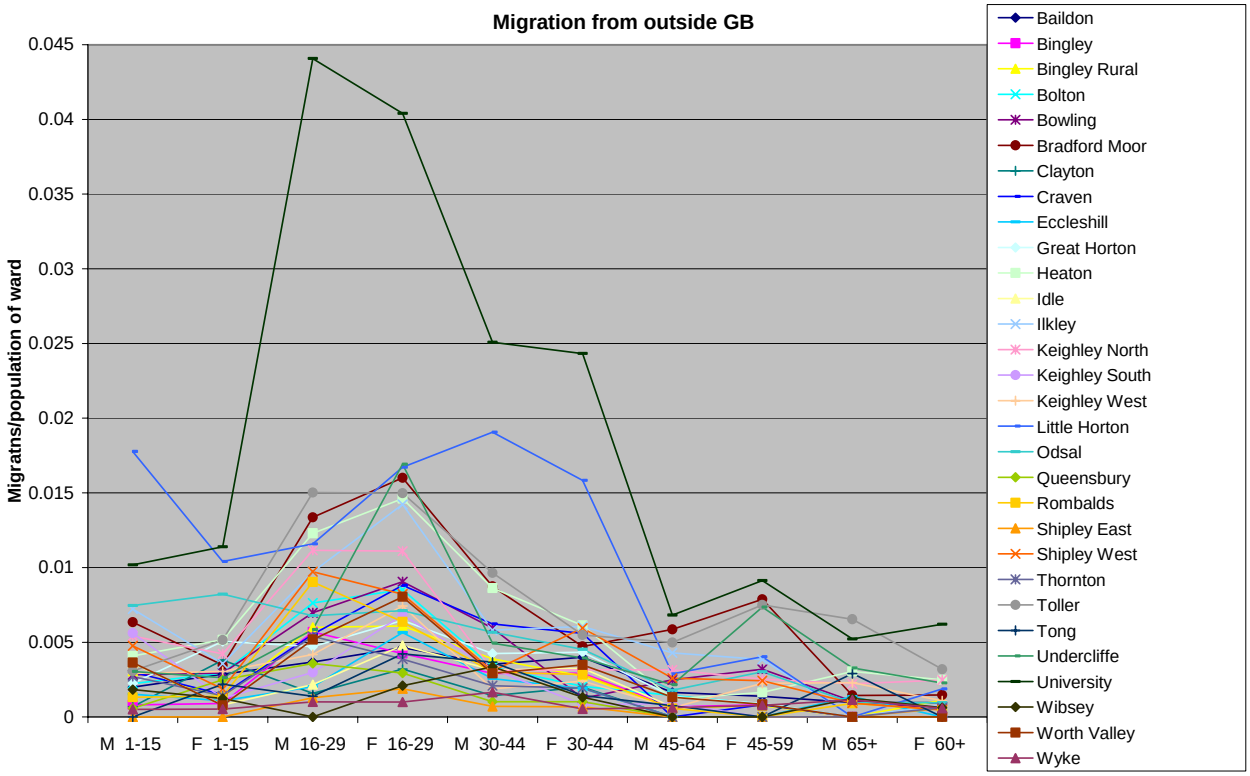


Source: 1991 SMS set 1, data provided by Ludi Simpson for Bradford ward-level projections

Here, as with the out to the rest of Great Britain, the highest migration rates occur in the 16-29 age groups for both sexes. These are taken to be student ages and migration attributed to joining the labour force. The in-migration rates are around the same general level as the out-migration rates; the exception that there is slightly higher in-migration to the wards Undercliffe, Heaton, Ilkley and Idle in the retirement ages. The wards Ilkley and to an extent Idle can be considered more prosperous wards from the indices of deprivation and ONS classifications. This could in part explain the small increase in migration rate for these wards at the retirement ages, however due to the small numbers involved and the fact that other less desirable wards have higher rates this cannot be the sole explanation.

The migration into the wards from overseas is investigated, shown in the figure 6:

Figure 6 Migration rate using the SMS to the Bradford wards from overseas (1991)



Source: 1991 SMS set 1, data provided by Ludi Simpson for Bradford ward-level projections

From the graph, it is evident that the in migration from overseas to some Bradford wards is occurring at much higher rates than for others. However, overall the in-migration rates are at much lower level than for the migration rates occurring for in, or out, to Great Britain. It is hard to establish if there is a pattern of the in-migration from overseas. This may be attributed to the small numbers. In total across all age groups and for both sexes, rounded to the nearest 1,000, there were 2,000 migrants from overseas into the Bradford district, as recorded by the Census (presented in figure 2). This is less than a tenth of the size of migrants for either in, or out, migration relating to the Bradford district-level. Nevertheless, a feature in fig.106 is that not only does the ward University have the highest in-migration rate from overseas for age group 16-29, it also has overall high levels of in migration from overseas. Another prominent ward, which has noticeably high in-migration rates form overseas, at least at the pre-retirement ages, is the ward Little Horton. Both University and Little Horton are urban multicultural city-centre wards and were the original settlement areas of the Bradford district as discussed by Richardson (2002:149). Whereas, more recently these city centre areas migration pull factors could be influenced by the University and Bradford College of Technology.

Overall, the SMS reliability may be questionable due to the small numbers for which the rates are based, however, on the other hand, Simpson (1995:50) makes the point that 'one cannot apply the district experience to each ward'. This was also apparent from the charts of migration rates from the SMS that not all wards had the same migration patterns. In a similar way to these charts of the migration rates for the Bradford wards, Simpson presents a graph of the wards gaining and losing at different levels, by the percentage in and out of the Bradford wards from the SMS, which ranges from just over 4% to almost 10%. Stressing the importance of using more detailed information that at the district-level.

Considering ethnic group migration, the 1991 SMS set (no2) does include ethnic group, however, it is only available at the district-level. From preliminary analysis using the 1991 SMS (set no2) on ethnicity group migration for the Bradford district Simpson (1995) finds:

- The South Asian population has lower levels of both in- and out-migration than the white population
- The net loss of population was greater in the South Asian communities than in the white community
- Most migration of South Asian communities of Bradford is with existing centres of those communities
- The overseas immigration to Britain of South Asians is double that from within Britain (Simpson 1995:53)

The findings could be used for setting assumptions, or differentials, in a population projection that is by ethnic group. However, given these will be based on small numbers, together with a possible undercount of people from minority ethnic groups and that trends do not stay the same, these may be used as a guide to inform along with other data sources.

1.2.1.3 Specially commissioned tables

Storkey (2002) provides a detailed account of how she attempted to take account of migration by ethnic group for the London boroughs using various specially commissioned 1991 Census tables. Storkey at the LRC initially considers a specially commissioned 1991 Census table number 49, that is by broad age-groups and gender for the ten ethnic groups. The commissioned table gave information on four types of moves: by moves within a London borough, between boroughs, between the rest of GB and each borough and finally moves outside GB to each borough (Storkey

2002:131). In considering the total in and out migration for the London boroughs from commissioned table 49, comparable with figure 2 the 1991 SMS Bradford district-level migrant counts, the counts were highest for the 20-29 age-group, which can be associated with ages entering the labour market. In addition, in total, also as with Bradford, there are slightly more female migrants in the 16-29 age-group (Storkey 2002:135). For which, considering female migration versus male migration overall, Storkey considers that there could be an effect of differential under-enumeration and presents the number of male migrants per 100 female migrants with and without an adjustment for under-enumeration. The findings highlighted that for all ages while in and out migration was 98 and 97 male migrants per 100 female, with the adjustment this increase to 101 and 100 (Storkey 2002:137). This stresses the importance of having a reliable base population in order to create any rates from.

1.2.2 NHSCR

The National Health Service central registers (NHSCR) are the closest data resource that Britain has to a population register. The NHSCR data records when people re-register with a GP after a move that has required a change in GP (the data source is introduced in Chapter 3 of the author's PhD (Williamson 2006)). The NHSCR, are operationalised for use by ONS through:

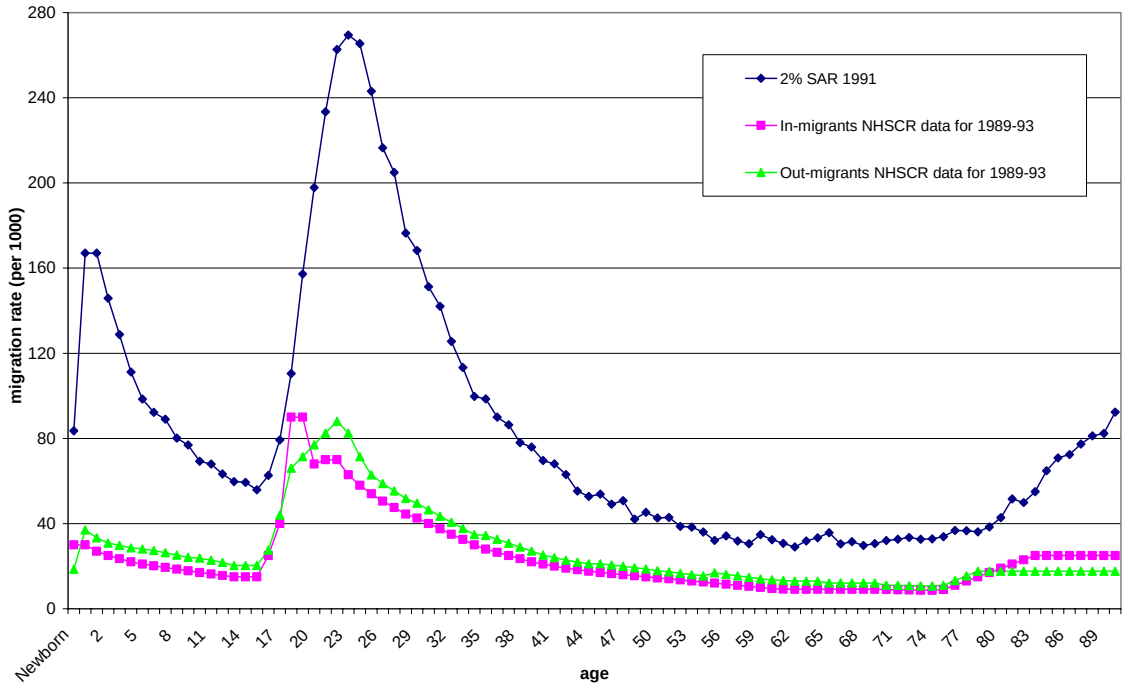
> each person's age, sex, old FHSA and new FHSA are extracted. Data covering each period of 12 months ending March, June, September and December are analysed to form the basis of the tables in ONS publications. NHSCR data was based at FHSA level up to 1998. NHSCR data is now based at HA level and is available at this level from the year ending June 2001 onwards. However, data for 1999 and 2000 was is based on Interim codes. This was a mixture of old FHSA codes and new HA codes. It was a transition period whereby we were only able to produce a mixture of FHSA and HA areas. (ONS 2006c:1)

While ONS may have access to a detailed form of the NHSCR, it is only freely available by 'GOR, UA and LA flows by quinary age-group and sex' (ONS 2004b:1).

The NHSCR have been used to account for migration in creating population statistics by ONS (again, population estimates and projections are described in Chapter 3 of the author's PhD research (Williamson 2006)). Storkey (2002) used NHSCR data subnationally in the London population projections. However, specifically for Bradford, previously NHSCR data has been used by Rees (1994) in creating population statistics for the Bradford wards. The method was described as a 'hybrid',

involving multi-state and multi-regional approaches. In addition, Simpson (2000, 2002), describes that the NHSCR data has been previously used in population projections for Bradford. Simpson (2000) used the NHSCR data from 1989-93 to create an ASMigR for 1991, these rates are compared with that of the ASMigR calculated from the 1991 SAR in figure 7 below:

Figure 7 1991 ASMigRs: UK rates using the 1991 SAR and Bradford district from NHSCR data



Source: 1991 ASMigRs: from the SAR as stated in fig.1, for the Bradford district provided by Ludi Simpson from NHSCR data

From figure 7 it can be seen that overall the level of migration is much lower from using the Bradford district NHSCR data than from using the migration rates from the 1991 SAR. The NHSCR is by no means flawless, for example, it misses moves for people that have not moved over administrative boundaries (very short moves), where patients can continue using their original GP. Simpson (2000:24) notes that the NHSCR are subject to an undercount, where this is greater for males. Moreover, Rees *et al*. (2000:9) also give details of the problems in using the NHSCR, 'they undercount migrations by young adult males who may migrate several times before registering; and they omit groups whose medical care is wholly provided by non-NHS bodies (the Armed Forces, the Prison Service, private health schemes)'. Other problems include lagged registration and that people may move and not inform their GP of the move (Simpson 1998:93). ONS (2002c) also considers their limitations for estimating migration. Nevertheless, given that most people are registered with a GP it

is the most reliable source, or estimate of the population, after the Census. For a more detailed introduction and quality issues surrounding their use see *making local population statistics* from the EwC Project (Simpson 1998).

The NHSCR is unsuitable for estimating migration according to ethnic groups. Ethnic group is not held in the data (Salt 2002); however, Scott and Vickers (2002) do consider the possibility of linking LS data with NHSCR.

1.2.3 Electoral roll data

Electoral registers (ERs) or roll data is a data source which results from the electoral canvass. The ERs are not for the whole population, it 'records people resident in the area who will be 18 or older at some time in the relevant year beginning February 16th' (Vann 1998:85). In addition, there are also some parts of the population not included, such as people from non-EU countries. For a more detailed information of the content of the electoral registers including concerns over the quality of the ERs see Vann (1998:85-89). ERs in their full format are not widely available, these are only made available for electoral purposes; nevertheless, the version that is available for purchase includes names of the electorate (Oxford City Council 2006; St Edmundsbury Borough Council 2006).

Therefore, it is possible to indirectly account for migration of the population aged 17+. Alternatively, ERs data could be incorporated into creating population statistics using one of the methods described in Chapter 3 part 2 of the author's PhD (such as indicator methods, outlined as alternative population estimation techniques compared to the widely used cohort component method). Regarding reliability, Simpson (1998) compares for 1996 the electoral count and the district patient count with the Bradford district population estimate. He found that the electoral data is slightly lower than the population estimate (99.8%), while the patient data is slightly over (104.8%).

The electoral data does not have any breakdown by ethnic group, however, as with mortality data, name analysis could be performed on the register which identifies South Asian and Non-South Asian names. This could prove a beneficial resource in areas with high proportions of South Asian populations. Previously, for Bradford, the package Nam Pechan was run on the electoral registers for the two overlapping time-periods 1991-1994 and 1991-1998. The results are reproduced in table 1:

Table 1 Change in the size of the electorate, ethnic group, 1991-1998

Electorate of Bradford District October of each year	All	Not South Asian names	South Asian names	South Asian names (changed for expected natural increase)
Electorate, 1991	345,395	309,428	35,967	
% growth 1991-1994	+ 0.7%	- 1.1%	+ 15.9%	+ 1.9%
% growth 1991-1998	+ 1.2%	- 3.3%	+ 40.4%	+ 2.4%

Source: Bradford MDC report (Simpson, 2000:27,table6.1)

From the outset it appears that there is a large increase (or potential in-migration) of South Asians in Bradford. Although, it must be stressed that this source does not fully capture the migration of South Asians, as Simpson (2000:27) points out that due to the youthful profile of the South Asians it would be expected to be a 14% increase by 1994 and 38% increase by 1998 anyway. Despite these limitations if the births by South Asians were known or estimated, given that they generally have a relatively young age structure which for practical reasons means very few deaths at older ages, one could estimate South Asian migration from the electoral register and then inform population projection assumptions.

1.2.4 International Passenger Survey (IPS)

The International Passenger Survey (IPS), was introduced in the author's PhD as

> the most prominent data source used to gauge international migration to and from the UK. The IPS is a survey of passengers and in total carries out a quarter of a million interviews each year, which equates to approximately 1 in 500 passengers (ONS 2002b), of whom 1% are migrants (Jefferies and Fulton 2005:17). The number of migrants captured by the IPS is reported as exceeding 2,000 per year for immigration, and about 700 emigrants (Rendall *et al*. 2003:224). These interviews are carried out at all the main routes out of the UK, including airports, seaports and the channel tunnel. The IPS asks respondents from the UK what their country of destination is or, for those coming into the UK, their country of origin (ONS 2002b).
>
> However, there are some concerns over the reliability of IPS migration estimates. These include that the IPS is based on intentions and does not necessarily reflect the reality and that the IPS does not cover all migration routes, excluding that between UK and Ireland (Jefferies and Fulton 2005; ONS 2003e). (Williamson 2006)

The IPS is the most obvious choice, after the Census, in trying to account for migration to or from abroad. It was described that the IPS is a sample survey that is asked on a voluntary basis at the main ports and it is criticised for the reason that it is only based on intentions. While 'IPS data are based on a sample and therefore have an error attached to them. However, a review of migration data sources concluded that

there is no better source of data for international migration' (ONS 2002a:13). It is available from ONS' MN Series on International Migration (Hollis 1998). However, the geographical breakdown is only GOR. Nevertheless, IPS data from 1993 onwards is available from UKDA, although, only since 1997 subnational information is included.

Bradford in particular, as stressed in the previous chapters, has had a long history of migration from overseas. The IPS information is recorded by country and not by ethnic group. Using the country as an indicator/proxy of ethnic group opens the argument over all the inconsistencies of the ethnic group and COB associations (this was discussed in the author's PhD (Williamson 2006)). Nevertheless, using country as a proxy for ethnicity, for the Bradford district, the problem with the IPS is that the numbers involved are so small, even over a long period of time. The adapted table, table 2 below produced by Bradford MDC (Simpson 2000) report shows that the actual counts over the 10-year periods before they are grossed.

Table 2 Adapted table 7.3 IPS estimates for Bradford

	1978-1988				1988-1998			
	Immigration to Bradford		Emigration from Bradford		Immigration to Bradford		Emigration from Bradford	
	Contacts	Grossed Estimate	Contacts	Grossed Estimate	Contacts	Grossed Estimate	Contacts	Grossed Estimate
All	449	17,931	95	15,070	101	14,730	31	7,696
South Asian	349	8,711	10	1,259	51	8,159	6	1,060
Other	100	9,220	85	13,811	50	6,569	25	6,636

Original source: ONS, Crown Copyright, 10 year periods July-June - reproduced and adapted from Simpson 2000:27,table7.3

From table 2 it is evident that even at the Bradford district-level, for the 10-year periods, the numbers before grossed are very small. Although, when grossed they at least provide some indication of the migration levels for the period. These estimates could be compared with the Census migration estimates, defined by the question on previous residence, to crosscheck the reliability of both sources for use as assumptions in population projections.

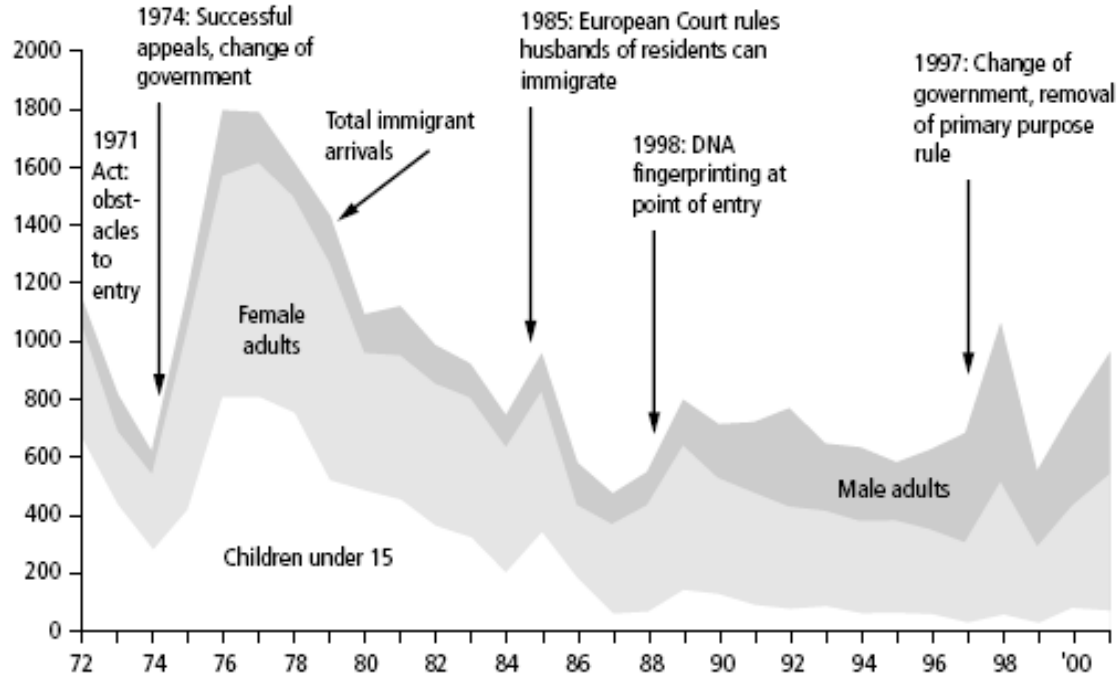
Finally, it is worth noting that despite the all weaknesses of the IPS, it is really the only basis of estimating emigration from the Bradford district, or from the UK in general (without involving data, such as population registers or Censuses, from receiving countries). No other UK data source captures this information. These rough estimates may be the only workable assumptions for use in a projection to account for migration to overseas. One can see from the table that the level of emigration from Bradford has dropped over the last decade, mainly to non-South Asian areas.

However, given that the contacts in this period were only 25 before grossing the reliability may be questionable. Moreover, Storkey (2002:179), due to the small numbers from the IPS, in accounting for migrants who moved overseas in creating projections, used national-level assumptions by COB and an average of three years data to create 'factors' to apply to London boroughs. The method was actually more complex than this involving 1991 Census data and IPS in-migration flows; however, even for London, with a large population, national-level assumptions had to be used.

1.2.5 Port health notifications

The port health notifications record the first destination address on arrival in to the UK from abroad (Simpson 2000, 2002). They can be used to gauge or compare estimates of migration from other data sources. Figure 8 below shows a time-series of the port health notifications at the Bradford district-level, the chart also indicates where there have been legislation changes that have impacted upon the migration levels into the Bradford district.

Figure 8 Port Health Notifications of immigrants to Bradford District (first address in Bradford)



Source: Simpson (2002:62,fig.3)

The data set provided from the records gives country of origin, which could be used as a proxy for ethnic group for some of the South Asian countries. There is also a broad age breakdown; this is 0-14, 15-59 and 60+. However, the data is only for the Bradford district and not by ward. The port heath notification data is also considered

since it is a potential source for cross validating other data sources. Simpson (2000) provides a comparison of migration from various different sources, shown in table 3:

Table 3 Comparison of overseas migration statistics for Bradford for period centring on 1991

Bradford	IPS, 1975-97 average	IPS mid-90 to mid-91	Census 1yr up to 21.4.91	Port Health Notes April-90 to March-91
Total Immigration	1,699	1,493	1,843	722
Total Emigration	1,181	1,224		
Total net	518	269		

Source: reproduced from the Bradford MDC report (Simpson, 2000:31,table7.1)

The table confirms that these different sources are recording in-migration to the district of the same level, which is reassuring that different sources are reporting the same features. The port health notifications record a slightly lower level of immigration, Simpson (2000:32) suggests this could be owing to fact that they record 'controlled immigration'. Overall, the cross validation by Simpson installs confidence into the reliability of sources that can be used to create subnational migration assumptions to build into projections.

The next section considers methods for smoothing migration rates for use in projections, in cases where the migration data has some SYOA, or age-group, detail.

1.3 Methodologies for modelling migration

The approach to modelling migration is similar to that of modelling fertility and mortality. Migration rates are can be ragged and fluctuate from age to age and a curve can be used to model these age-specific rates in order that the rates are smooth in a form which can be used in a population projection. Although, due to the differences in migration patterns by age, the curve is more complex than those used to model both fertility and mortality rates. It has more peaks and can require up to 13-parameters to account for the different migration behaviours by SYOA, yet,

> Schedules of migration rates tend to show regular features such as a peak in the young adult ages and declining migration propensities in old age, though there may be elevated migration around retirement
> (Congdon 2005:F-1)

Andrei Rogers and others, for over 25 years now, have been developing what is readily known as the 'multi-exponential' model schedules for migration. This began with Rogers *et al*. (1978). Preston *et al*. (2001) explain that Rogers and Castro (1981c) have essentially, in relation to migration, taken a 'mathematical approach equivalent to establishing a "law of mortality"' (Preston *et al*. 2001:208).

1.3.1 Development of model migration schedules

From the literature on model migration schedules many of the papers are used in interregional migration. Ananta *et al*. (2001) explain the reason as to why only out-migration is considered by Rogers *et al*.

> They do not study in-migration because in-migration to region A from region B is simply out-migration from region B to region A. In addition, it is difficult to find the denominator of the in-migration. The denominator must be potentially in-migration in the world. (Ananta *et al*. 2001:5)

They also describe how the migration curve has changed from the original version, such as when Rogers and Castro added another component to the migration schedule making it an 11-parameter version. Today the full multi-exponential model migration schedule can be represented by a full 13-parameters (Rogers *et al*. 2004; Raymer and Rogers 2006). The multi-exponential model migration schedule has been modified over the years to a 13-parameter version to account for the pattern of migration by age.

The curve is described next. The progression of the model migration curves has been essentially developed out of interregional migration studies, which will not fully be addressed here. The reason for not researching into interregional and ultimately multiregional approaches to population projections is that in the projections that are being produced here, for Bradford, are using the forecasting package POPGROUP[2] which takes a uniregional approach. That is the Popgroup package applies a uni-regional projection to the areas/groups. Where each area/group is projected separately, and then POPGROUP sums these (it packages up all of the population subgroups) in order that information is available for the larger area/group of interest. This process in POPGROUP is not using transition probabilities. For further information on multi-regional approaches, see *Introduction to Multiregional Mathematical Demography* by Rogers (1975) or *Spatial population analysis* by Rees and Wilson (1977).

Rogers and Little (1994), describe the full model, there are five parts that constitute the 13 parameters:

[2] Developed by Bradford Council and Andelin Associates and has been used to assess both rates created in this working paper and the author's PhD research.

(a) a constant term a_0

(b) a two-parameter (a_1, α_1) negative exponential curve
$m_1(x) = a_1 \exp(-\alpha_1 x)$

(c) a four-parameter $(a_2, \alpha_2, \mu_2, \lambda_2)$ double exponential curve
$m_2(x) = a_2 \exp\{-\alpha_2(x-\mu_2) - \exp[-\lambda_2(x-\mu_2)]\}$

(d) another four-parameter $(a_3, \alpha_3, \mu_3, \lambda_3)$ double exponential curve
$m_3(x) = a_3 \exp\{-\alpha_3(x-\mu_3) - \exp[-\lambda_3(x-\mu_3)]\}$

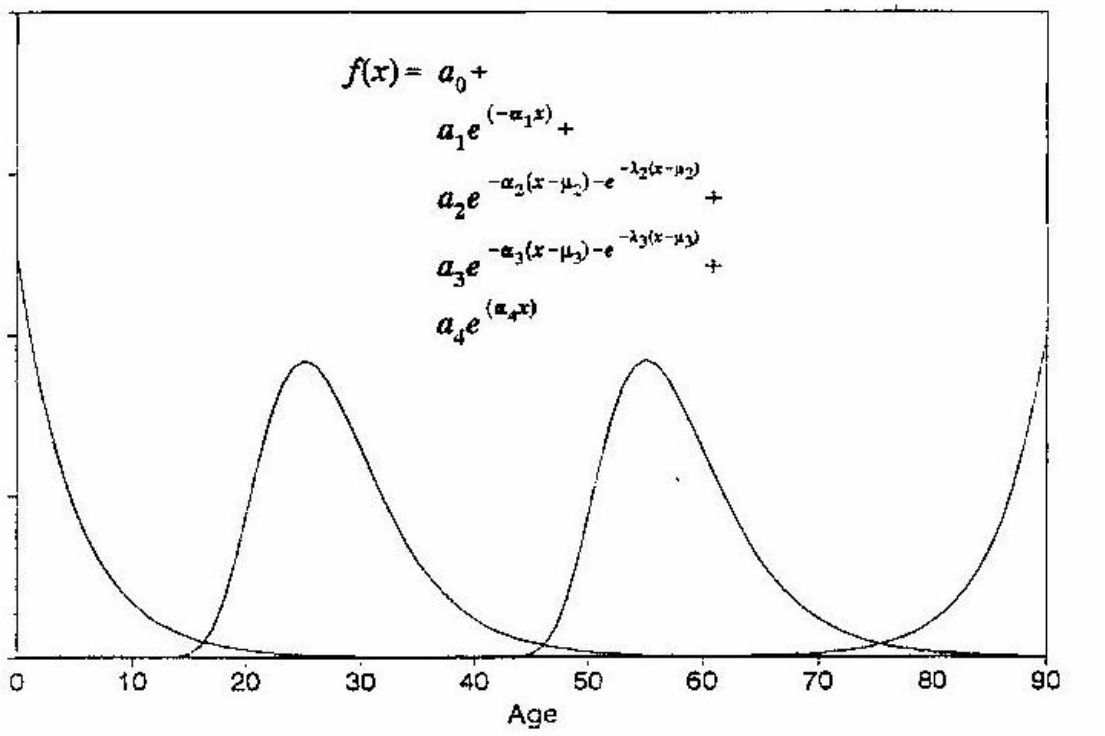
(e) a two-parameter positive exponential curve $m_4(x) = a_4 \exp(\alpha_4 x)$.

The sum of the above five components defines the full multiexponential model schedule: $m(x) = a_0 + m_1(x) + m_2(x) + m_3(x) + m_4(x)$.

(Rogers and Little 1994:176)

The full impact of these five components can be viewed in figure 9, where all the curves are easily distinguished. Overall, the a's in the equations are level parameters and the rest of the parameters set the shape by age Rogers *et al*. (2004). Moreover, the components are also described in detail by Rogers and Castro (1981a, 1981c), Rogers and Little (1994), Rogers and Raymer (1999a) and Raymer and Rogers (2006).

Figure 9 Model multi-exponential migration schedule - by Rogers and Little (1994)



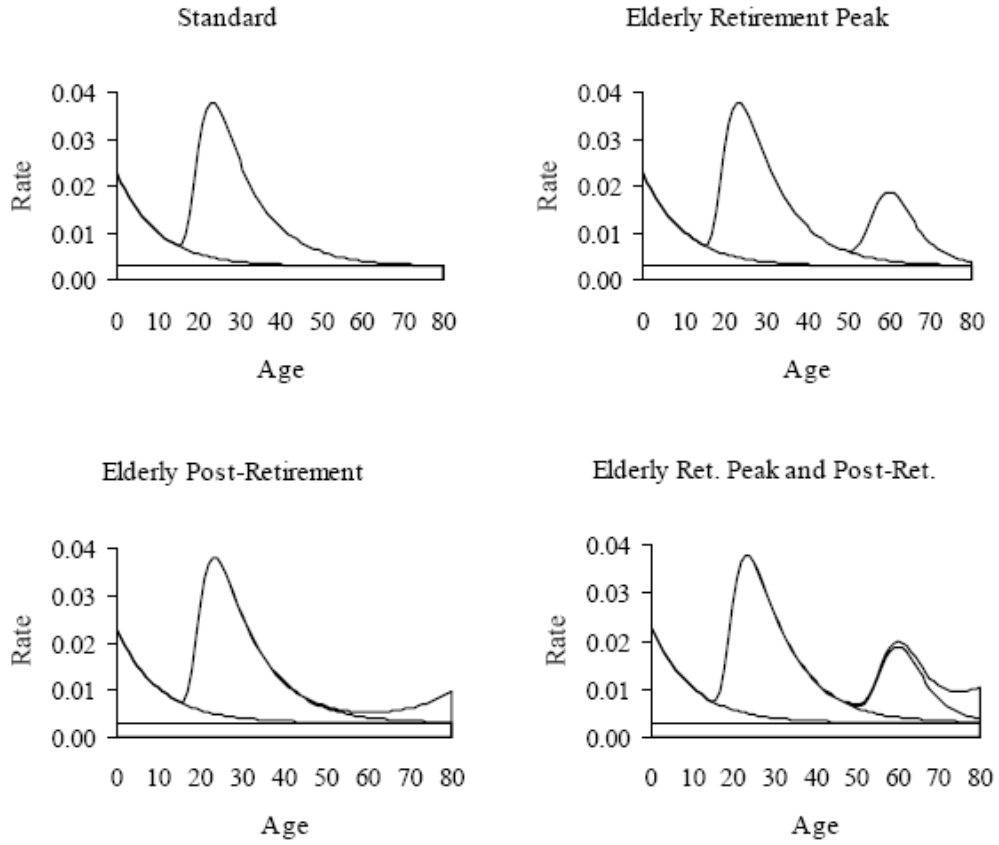
Source: Rogers and Little (1994:117)

Figure 9 shows all the components: the pre-labour force, the labour force and post-labour force. In most examples Rogers (and others) when using the model schedules

have changed the gross migraproduction rate (GMR) or intensity, to equal 1, or ‘unity’ (Bates and Bracken 1982) The GMR is a standard measure, similar to the Gross Reproduction Rate (GRR), in that it is the sum of the ASMigRs (Rogers and Castro 1981b:4). Bell *et al*. (2002) discuss to divide through by the GMR can be useful to compare schedules from different countries, giving an example for GB and Australia.

Congdon (1993:255) discussed that all models have full and reduced forms. The multi-exponential can also take reduced forms depending on the complexity of the migration data. Rogers and Little (1994) in describing the five components mention that the retirement component can be zero. This contributes to the way in which the curve can vary from 7-parameters to the full 13-parameter model. Moreover, in fitting the model schedules when it was the previous 11-parameter version, it was noticed that the retirement peak was often not pronounced and there was evidence of an upwards slope; Rogers and Castro (1981a:84) proposed a modified 9-parameter model instead. Thus, there are a few different versions of the model that, depending on whether there is evidence of retirement migration in the schedule of migration rates, could be used. That is depending on the shape of the migration rates the curve can be fitted either to the full model, model modified for no retirement migration or to include an ‘upward slope’ for post retirement migration. In addition, Raymer and Rogers (2006) generalise migration schedules into four families, the standard, young standard, old standard and early retirement using interstate migration from the US West region for the period 1985-1990, where the different families use different numbers of parameters to account for the age-pattern. Figure 10 below displays these:

Figure 10 The four main families of model migration schedules: standard, elderly retirement peak, elderly post-retirement upslope, and elderly retirement peak and postretirement upslope



Source: Raymer and Rogers (2006:3,fig.1)

Moreover, for UK data, Bates and Bracken (1982, 1987), Boden *et al*. (1991) and ONS (1999, 2004a) did not require all the parameters when fitted to subnational data.

1.3.2 Implementation of the model migration curves

The model migration schedules have been described in detail as part of the methods review. In this section examples of the migration curves implementation are given. Before even considering the application of the migration curves data issues must be addressed; similar to that of fertility and mortality, there are problems of data being provided in five-year age-groups. This has in part been addressed by Rogers and Castro (1981a, 1981c), Rogers and Raymer (1999a) and Congdon (2005). Rogers *et al*. have used cubic splines to disaggregate data to SYOA. Full details of splines are not given here; splines were introduced in the author's PhD (Williamson 2006)[3].

[3] For specific examples of using splines on migration data see Rogers and Castro (1981a) or Rogers and Raymer (1999a).

Application of the model schedules have over the years been used on a variety of data from different countries. In the International Institute for Applied Systems Analysis (IIASA) Rogers and Castro (1981a) had built up a collection of 510 different schedules, plus they had 56 schedules that they deemed 'extreme'. They did have some problems in fitting the curves; this was for the parameter for the constant. The problem was it sometimes took negative values, if this occurred they set it to the lowest observed rate (Rogers and Castro 1981a). In addition, Rogers and Little (1994) changed the levels and carried out some sensitivity analysis using the model schedules. Fitting of these schedules by Rogers and others was carried out by means of non-linear regression using the Levenburg-Marquardt algorithm (for example, Rogers and Castro 1981a, 1981b). It is the standard algorithm when specifying a non-linear regression using the package SPSS and can easily be used when using SAS[4].

Considering the fitting options of the migration curve, Rogers and Raymer (1999b) used the IIASA created package MODEL (written in FORTRAN) which allows the users to program in equations for all demographic rates, and compared this with the 'off the shelf package' Table Curve 2D (TC2D), version 4 by Jandel Scientific. Overall, they appear to favour the TC2D for its ease of use, over the in-house developed, MODEL. The only problem encountered was that in TC2D the user could only specify up to ten parameters, not all 11-parameters could be included, meaning one parameter had to be set to a fixed value. That is they used TC2D to fit the migration schedules fixing the constant parameter for all the schedules estimated (Rogers and Raymer 1999b). Rogers and Raymer (1999b) comment that TC2D may be more attractive to 'nonprogrammers' due to being more user friendly than MODEL. Moreover, in considering fitting migration curves in general statistics packages Raymer and Rogers (2006:35) note that TC2D has the advantage of having a graphical interface which is 'very useful for obtaining the initial estimates'.

1.3.3 Application of model schedule - including subnational application

The intention of this overall section is to introduce methods to smooth migration rates from the literature. The model migration schedules have been used at the national and

[4] This algorithm was used in the author's PhD research when fitting the 3-parameter Hadwiger function to the Bradford fertility data in both SPSS and SAS.

subnational-level, however, as far as can be found in the literature they have never been applied at the ward-level. The application of model migration schedules have been used internationally. Rogers *et al*. (2004) name specific examples of where the multi-exponential migration curves have been previously used:

> migration flows between local authorities in England (Bates and Bracken, 1982, 1987), Sweden's regions (Holmberg, 1984), Canada's metropolitan and nonmetropolitan areas (Liaw and Nagur, 1985), Indonesia's regions (United Nations, 1992), the regions of Japan, Korea and Thailand (Kawabe, 1990), and South Africa's and Poland's national patterns (Hofmeyr, 1988, Potrykowska, 1988). Finally, Statistics Canada has adopted the multiexponential model migration schedule to produce its provincial population projections (George et al., 1984) and doctorial dissertations have applied it to represent interregional migration flows in Mexico (Pimienta, 1999) and in Indonesia (Muhidin, 2002).
>
> (Rogers *et al*. 2004:1)

In view of the model migration curves in the UK, Rogers *et al*. mention their application for use in LAs by Bates and Bracken. However, previously, back in 1981 Rogers and Castro used data for 1970 for ten specified regions in GB, although not for intraregional migration (Rogers and Castro 1981c17). This resulted in, for males: 59 schedules without retirement peaks and 23 with retirement peaks, and for females: 21 schedules with retirement peaks and 61 without. Then in 1982 Bates and Bracken applied a modified (re-parameterised) version of the curve to 116 subnational areas in England and Wales (at the district, borough and shire-level) using data on usual residence from the 1971 Census. Due to the small numbers problem they could only fit the data for ages 0-70. Overall, they found 'that twelve different areas types could be identified. Accordingly, the data were amalgamated, and the profiles were recalculated for these twelve types' (Bates and Bracken 1982:898). In 1987, they essentially did the same using the 1981 Census data, for England only this time. Bates and Bracken also provided a comparison with their earlier work for the LAs migration for the time points[5]. In addition, various versions of the migration curves have also been used subnationally by OPCS/DoE and ONS over the years (Boden *et al*. 1991; Wood *et al*. 1999; ONS 1999, 2004a), and even they were even used in the recent ONS ethnic group estimates (Large and Ghosh 2006).

[5] Form their work the GMR for Bradford was lower in 1981 compared with 1971, and in both cases the Bradford there was more out-migration than in-migration (Bates and Bracken 1987:534).

Congdon has also used migration curves; in 2005 he presented various approaches to modelling migration from Scotland to England and from England to Scotland using the Rogers and Castro (1981) curve and variations: comprising Bayesian approaches using MCMC (Markov Chain Monte Carlo) sampling. This also included the pooling of strength over migration curves; this was over male and female schedules. In addition, previously, Congdon (1993) subnationally, for London, gave a detailed example of the application of the model migration schedules. This was a modified version which had 10-parameters using NHSCR data, the version of the curve was:

$$r(x) = a_1 \exp(-\alpha_1 x) + a_2 \exp[-\alpha_2(x-\mu_2) - \exp\{-\lambda_2(x-\mu_2)\}] + a_3 \exp\left\{-\alpha_3(x-\mu_3)^2\right\}$$

Congdon used the curve to estimate the parameters each year for the 15 year period 1975-1990. Congdon presents parameter estimates and reports increases in the values of α_2 and μ_2 over the years - parameters associated with the labour market migration.

Considering the parameter values, work by Rogers and Castro (1981a), admittedly on interregional migration, found that the parameter values for some of the parameters were of a similar level. For instance, for the labour market migration ages, parameters α_2, μ_2 and λ_2 were recording similar levels of values, these are found to be between $17 < \mu_2 < 22$, $0.10 < \alpha_2 < 0.20$ and $0.25 < \lambda_2 < 0.60$ in over 500 sets of migration rates (Rogers and Castro 1981a, 1981c; Rogers and Little 1994; Rogers *et al*. 2004). This highlights the regularities in migration schedules across different countries and times.

Finally, in applying migration rates to subnational data, Congdon (1993) provides an alternative option to deal with migration rates. He takes a relational approach, through using life-tables and using the rates from the average of the fifteen year period from 1975-1990 from the NHSCR data as a standard. Congdon (1993) finds the fit to the data is 'considerably better' than using the modified 10-parameter curve[6]. However, Congdon points to caution over basing forecasts on these and suggests that as there are more years of NHSCR data there will be more potential for using these. A relational approach was also considered by Rogers, specifically Rogers and Castro (1981a).

[6] given in the equation above

Given high data requirements of using a relational approach, it is not fully considered. However, the next section describes a pragmatic solution for the Bradford wards.

1.4 A possible strategy to account for small area migration in population projections

This section provides a practical strategy option to indirectly account for small area migration incorporating a population estimate as a constraint - also known as a target or local anchor. This may be a pragmatic option for producers of small area/group population projection where the projection starts in the past, such as the 1991 Census year. The way in which this works would be to add in the known births and deaths that occurred over the period, and incorporating recent reliable estimates of the population to give an indication of the migration that must have taken place in order to meet the estimates. The reliable estimates could be for a larger area, such as a population 'target' taken from the district-level mid-year estimates (MYEs) from ONS, or for smaller areas for using only a section of the population (adults only) using electoral register data as the 'local anchor'. Although, since the recently produced ONS small area/population and ethnic group estimates are available these could be confidently used as a reliable 'target'/constraint (ONS 2005a, 2006a, 2006b).

One way to achieve this is using the population-forecasting package POPGROUP. Described below is an example for the Bradford wards using small area estimates produced by Bradford MDC and ASMigRs from the 1991 2% SAR (as the dependable age-structure which will hold constant throughout the projection period).

1.4.1 Migration through using a population constraint in POPGROUP

All the steps are describe below with regards to data sources and what was carried out on the data in order for it to be operationalised within POPGROUP. For the most part these have been described in detail in Chapter 4 of the author's PhD, which presented the natural increase population projections of the thirty Bradford wards. The only difference is that the base population for the wards was not scaled to the most recent 1991-MYEs revisions. However, the aim is to present an example of a strategy that may be used to account for migration in projections that start some years in the past. Population estimates for an intervening period are used as a constraint to account indirectly for migration that must have taken place. Table 4 shows all the data used:

Table 4 Data and assumptions for the Bradford ward-level population projection incorporating a population contraint to account for migration (starting in 1991)

Component in projection	*Data source used*
Base year population	1991 Census augmented for non-response
Population constraints after the first year	1992, 1996 & 2000 SAP Estimates based on patient database for each ward, noting that for 1992 using (SAP96 - Ward Popln1991)/5 + Ward Popln1991
Births since base year	ONS table VS4, mean of adjacent calendar years 1991-2000
Fertility differentials or TFR	Average TFR, from Popgroup output for last 3 years for which births were input mid91-mid99
Future trend of births/fertility	Trending on the TFR from 2000
Deaths since base year	As Births
Mortality differentials or SMR	As fertility
Future trend of deaths/mortality	As fertility
Migration differentials or SMigR	Differential for 2000 from average of 1991-1999 from Popgroup output (in same way for fertility and mortality)
Future trend of migration	Trending on the SMigR from 2000

Details of the natural increase part of the projection were described in Chapter 4 of the author's PhD (Williamson 2006); briefly, they were accounted for in the projection by:

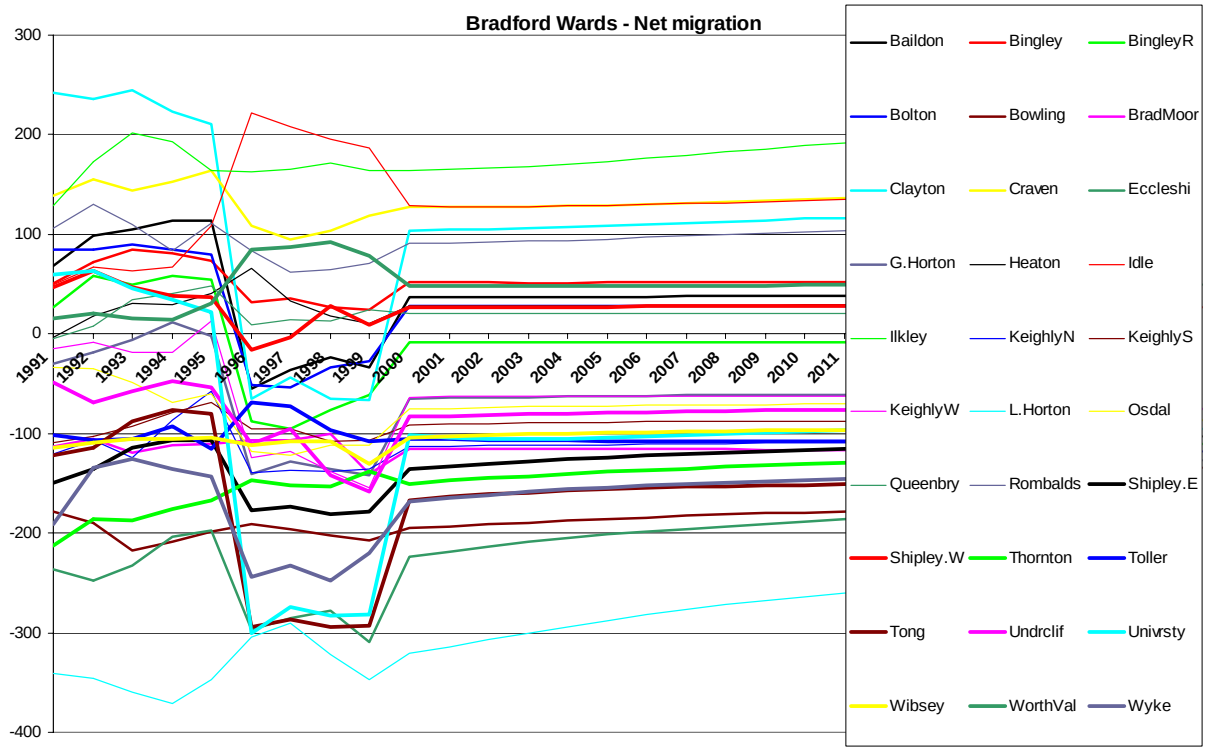
- Entering the mid-year birth and deaths for years 1991-2000 calculated from actual counts for each ward
- Using the recalculated TFR and SMR produced by POPGROUP (taking the average of last three years)
- This produced fertility and mortality differentials specific for each ward to project forward from year 2000
- Overall impact changed the ward-level fertility and mortality

Using population constraints, migration that must have taken place was captured by:

- Entering recent population estimates for the years 1996 and 2000 to act as a constraint on the population for wards
- POPGROUP changed the migration figures to be consistent with the constraint
- Using the resulting forecast to produce migration differentials to extend forward from 2000 (using average of implied migration over the years)
- Lastly using a district-level population estimate for years 2001 to 2021 as a population constraint (this step is optional, it was included as had been the results from the 1991-based ethnic group Bradford district projection).

The bringing all of these together, the projection, starting in 1991, and using the population estimates for 1996 and 2000, POPGROUP changed the migration rates to meet these population constraints. The impact of this can be seen in figure 11 below of the net migration for the Bradford wards (produced from the POPGROUP reporter). Noting that the chart is of the counts of the net migrants for each ward (not a rate).

Figure 11 Impact of using population constraints in the ward-level population projection for Bradford



Source: Bradford ward-level projections, created in 2002 (and not scaled to the most recent ONS 1991 MYEs) for Bradford MDC (and also presented at BSPS by Williamson and Simpson (2002))

The constraint, or population targets, operates by apportioning the people using the constraint to the initial estimate depending on the type of constraint. That is whether it is by age or simply a total for wards or the district. The impact of the constraint can be identified for the years 1996 and 2000, where there is a change to the net migration taking place. For future years, an average of the migration rates has been applied and trended.

Whilst it can be argued that this may not be the most scientific approach to dealing with migration, it is however only one of the few options available due to the lack of reliable migration data at the ward-level. This is a pragmatic strategy of using population estimates to account for migration that has taken place, while at the same time using the national-level ASMigRs schedule (from the SAR) gives a reliable age-pattern to the migration rates.

1.5 Concluding findings concerning migration estimation for small groups

This working paper started by presenting the main data sources that record migration, which could be used to create population statistics or at least inform assumptions subnationally. It was apparent that migration information according to ethnic groups

is rare, and while there are some sources that record country or country or birth, these counts of migrants can be small when considered subnationally, the IPS for example.

The next section introduced the use of model migration schedules developed by Rogers *et al*. over the years, these can require up to 13-parameters, depending on population characteristics, and gave examples of their use subnationally, but not at the ward-level.

The final section provided a pragmatic strategy to indirectly account for the migration that must have taken place using population constraints (targets/local anchors). This was using population estimates created by Bradford MCD for 1996 and 2000 and using this to create migration differentials for each ward (shown in figure 11 of the total ward-level net migration), the ward's migration experience differs. While there may be some debate over if this is an appropriate way to account for migration given there are the SMS for example. However, it will be argued that data from the Census could be used to confirm trends found when using these indirect methods. Using Census data could also be incorrect, since for whatever reason, changes to immigration or visa restrictions, the migration for the Census year could be atypical. Moreover, Simpson (1995:49) noted that for Bradford that 20% of the migrants moving in to Bradford from the 1991 SMS had no origin code, which means that any assumptions (and figures 2, 4 and 5 showing the rates) based on them will be an underestimate. Finally, with ONS recently producing small area/population estimates and ethnic group estimates (ONS 2005a, 2006a, 2006b) the indirect strategy method could be made more reliable than using a district-level MYEs or using information from administrative sources. Nevertheless, from the migration provided from these sources it was apparent that migration differs for the wards. This finding is similar to that when considering fertility rates at the ward-level for Bradford from the author's PhD research, where there were great variations of the overall fertility level at the ward-level, it varied from a total fertility level of 1.56 to 2.87 (Williamson 2006). This, as with results presented in the author's PhD, is demonstrating the need for detailed migration information to inform assumptions for use in population projections.

1.6 Potential future research

The review of data sources and methods has uncovered the possibility of smoothing the district-level NHSCR rates or district-level rates created from the SMS using a version of the multi-exponential migration curve. In addition, another option could be

to extend work presented in the PhD research by the author (Williamson 2006) on age-specific fertility rates (ASFRs), whereby 'Bradford fertility areas' were created (which were groupings of wards based on cluster analysis and the 1991 ONS classification of wards). Rates for these 'fertility areas' could be smoothed by using a migration curve depending on the numbers of migration events and population sizes

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