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# MIGRATION BETWEEN METROPOLITAN AND NON-METROPOLITAN REGIONS IN THE UK

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## Abstract

Two different types of data are adopted in this paper in order to show the level, spatial pattern and age structure of migration between a set of twenty metropolitan counties and non-metropolitan regions in the UK. Five year 'migrant' flows from the 1971 Census are used to describe characteristics of inter-zonal mobility during 1966-71, while annual 'movement' flows from the NHSCR enable trends since mid-1975 to be examined. It is argued that a system for migration projection should be designed to include a series of alternative methods but preference is given to historical dependence models in the short term since this is consistent with the empirical evidence of stability in spatial structure despite decline in the overall level of mobility.



Paper presented at the Anglo-Dutch Migration Symposium, Soeslerberg, Netherlands, 14-16 September, 1983.

October 1983

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## 1. Introduction

Explanation of historical migration behaviour is rarely straightforward because of the wide variety of influences upon the decision to migrate and upon the decision to choose one particular destination rather than another. Nevertheless, analysis of historical data is a necessary prerequisite to projection and forecasting because it enables more informed hypotheses to be suggested about the likelihood of migration in the future. In turn, improvements in the forecasting capability will mean improved strategic planning and ultimately a more satisfactory distribution of resources and public services.

In the United Kingdom the redistribution of the population through migration has become the most significant influence upon subnational population change and upon the differential growth of cities and regions. This paper stems from a wider research project designed to investigate the processes of spatial population change in the UK since 1961, and to develop a multi-region population projection system which links migration models with accounts-based population models (Rees and Stillwell, 1982).

The following section contains a description of the age-disaggregated data on migration which is available from the 1971 Census 'new area' tabulations and from the Office of Population Censuses and Surveys' (OPCS) 10% sample of National Health Service patient re-registrations since 1975. The limitations of both types of migration data are discussed and methods of estimating complete matrices of flows for a system of metropolitan counties and non-metropolitan regions are outlined. Section 3 presents some of the characteristic features of migration for this system of zones and particular attention is paid to the spatial pattern and age structure of five year migration during 1966-71 and changes in the pattern between 1966-71 and 1976-81. The distance decay parameters of a doubly constrained spatial interaction model are used to illustrate spatial variations in the propensity to migrate over distance, and trends in the level and pattern of annual inter-zonal movement are examined.

In section 4 of the paper, alternative methods of migration projection are considered and four different approaches are chosen to generate forecasts of age-specific flows which can be compared against estimated 'observed' data using a goodness-of-fit statistic measuring the average deviation for each age group.

## 2. Study Area Zones, Data Sources, and Estimation Methods

### 2.1 Metropolitan and Non-metropolitan zones

Several alternative sets of areas have been used for the analysis of migration in the past including standard economic planning regions at a relatively coarse level (Department of Environment, 1971) and local government districts at a finer scale (Martin, Voorhees and Bates, 1981). Analysis at a finer scale usually means the sacrifice of age and sex detail. The selection of study zones is important because of the motivations which tend to stimulate migration over different distances. In some studies (Hyman and Gleave, 1978) regionalization methods have been used in an attempt to distinguish longer distance employment-related migration from shorter distance migration influenced by the desire to change home without changing employment.

The standard regions are probably the most convenient set of administrative zones to work with because of the wealth of published data which exists at the regional level and because much has been learnt already about modelling at this level. However, the regional scale does obscure one of the most important spatial characteristics of the migration pattern over the last two intercensal decades; namely the migration of persons from densely populated urban cores to more sparsely populated rural areas (Census Division, OPCS, 1981). Ideally, it would be appropriate to work with a set of local government areas but this was considered beyond current capabilities in terms of purchase and release of unpublished data.

A system of zones has been selected which include the metropolitan counties, their region remainders, the remaining regions without metropolitan counties in Great Britain, and Northern Ireland (Figure 1).

One advantage of this set of twenty zones is that age-specific migration data is available from special tabulations from the 1971 census for the areas as constituted on 1 April 1974 for England and Wales and on 16 May 1975 for Scotland (OPCS, 1978). This enables comparison with sets of data for later periods. The analysis focusses on five year migration and five year age groups in order to avoid problems of sparse matrices which arise if data is available for single year migration and one year age groups. A further consideration is the need to limit the size of the computing task involved.

### 2.2 Census transition data: five year migrant flows

Migration statistics derived from the results of national population censuses are frequently used for analysis in the UK in the absence of a population registration system. Prior to 1961, respondents were asked to identify their place of birth and place of usual residence. Consequently, analysis was


Figure 1. Metropolitan and non-metropolitan zones in the UK

undertaken of 'lifetime' migration in the nineteenth century (Ravenstein, 1876), and in the first half of the twentieth century (Osborne, 1956).

Since 1961, respondents to censuses have been asked to identify their place of usual residence either one year or five years beforehand. Five year information is only available for the periods preceding the 1966 and 1971 censuses. The intermediate census taken in 1966 was organized on a 10% sample basis, whereas the migration data associated with the 1961 and 1971 censuses is based upon the selection, at random, of one household from each run of 10 private households and of one person from every 10 persons enumerated in non-private establishments.

Research studies based on published and unpublished census five year transition data at various spatial scales are numerous since censuses are more comprehensive and reliable sources of information than registers or surveys. Published flows between standard regions have been examined by Rees (1979 ) and Stillwell (1978), and used in projection contexts by Joseph (1975), while other studies have considered migration between aggregated counties (Stillwell, 1979) and flows associated with specific counties (Craig, 1981). Flows within and between Metropolitan Economic Labour Areas, on the other hand, are described in Kennett (1980). More detailed, unpublished information has been extracted from the 1971 Census 10% migration file (Edwards and Pender, 1976) and used to prepare reports on intra-regional migration in Wales (Welsh Office, 1979), and Yorkshire and Humberside (Department of Environment, Yorkshire and Humberside Regional Office, 1979). Data on flows between local authorities in the London Region, disaggregated by social class, has been extracted from the same source and used by Gordon (1982) for example, to separate migration streams according to motivation.

Despite the reliability of census information, the migration data is not without its limitations and these are well known (Rees, 1977 ). It is appropriate to think of census figures as numbers of migrants rather than migrations because they refer only to those persons who were in existence five years prior to the census, who migrated (at least once) during the period to a different place of usual residence and who survived the period. Various migrant subgroups are omitted from transition statistics. One such group are the infant migrants or those aged less than 5 years on census date, who were not in existence at the commencement of the 5 year period. Persons who migrated and then died during the period are another group which is excluded. In addition, migrants who were resident at the same address at the start and end of the period, but who might have lived elsewhere in between are not recorded. The incidence of return migration is difficult to measure and it can be argued that return to the same address is less significant than return to an address in the same locality. In the latter case, the migration is recorded as a short distance migration within the same area which has probably not involved the migrant in crossing an administrative boundary, perhaps concealing the fact that two or more longer distance, inter-regional or international moves may have been undertaken. Multiple migration is omitted from census figures because transition data represents a count of persons experiencing migration rather than the number of times each person moves. Certain unknown flows can be estimated through the construction of population accounts (Rees and Wilson, 1977) but several, such as surviving infant migrants, are required as inputs to the accounts-based model, and must be determined independently. Infant migrants can be estimated as a function of migrants in the 5-9 age group and single year flows as follows:-

$$\begin{matrix}\text{5 year}\\ \text{migrants aged}\\ \text{0-4 at census}\\ \text{1971}\end{matrix} = \left[\begin{matrix}\text{5 year}\\ \text{migrants aged}\\ \text{5-9 at census}\\ \text{1971}\end{matrix}\right] 0.5 \left[\begin{matrix}\text{9/8 1 year migrants}\\ \text{aged 1-4 at census,}\\ \text{1971}\end{matrix} \Big/ \begin{matrix}\text{1 year migrants}\\ \text{aged 5-9 at}\\ \text{census, 1971}\end{matrix}\right] \quad (1)$$

Migrants in age categories 75-79, 80-84, 85-89 and 90 + are estimated by deconsolidating flows in the last migrant age group (75+) using proportions based on 1971 population totals.

One set of internal migration flows unavailable from the census tables is the set of flows from zones in Great Britain to Northern Ireland of persons in each 5 year age group. The first stage of estimation requires the total number of migrants to Northern Ireland from each zone. Northern Ireland Migration Tables (GRO Northern Ireland 1975, Table 1B) yield figures of inmigration from England, Wales and Scotland but with no subnational breakdown. If we assume that the distribution of outmigration flows to Northern Ireland from other zones is equivalent to the distribution of inmigration flows to other zones from Northern Ireland, the total outflows from England and Scotland can be deconsolidated into zonal flows according to the inmigration proportions. It is surprising to find that over 20 thousand inmigrants are recorded with an area of origin which is 'not stated'. There is some uncertainty as to whether these represent British troops stationed in the province since over half the numbers are female. The 'not stated' inmigrants can either be ignored or distributed proportionately between the origin zones.

The second stage of estimation involves generating age-group flows from aggregate zonal flows. A simple method is to assume the same age breakdown as that associated with all other internal migration flows. Estimated migrants ($\hat{M}$) from zone i to N. Ireland (NI) in age group a at census date 1971 are

are determined using:

$$\hat{M}_a^{iNI} = \left[ \hat{M}_*^{iNI} \Big/ \sum_a \left( \sum_{j=1}^{19} M_a^{ij} \right) \right] \quad \sum_{j=1}^{19} M_a^{ij}, \quad j \neq i \qquad (2)$$

where $\hat{M}_*^{iNI}$ represents the non-disaggregated totals estimated previously. An alternative method of deriving these flows is through calibrating model migration schedules (Rogers and Castro, 1981) for outmigration from each zone to the rest of Great Britain. Model migration rates for each age group provide the basis for disaggregating the totals of outmigration to Northern Ireland from each zone. To exemplify this, the observed rates of outmigration from Tyne and Wear to all other zones in Great Britain have been standardized by the gross migraproduction rate, the sum of the age group rates, and a non-linear least squares algorithm has been used to estimate the parameters of a reduced model migration equation. The model schedule is plotted in Figure 2, and the model equation has the form:

$$m_a^{i*} = b_1 e^{-\alpha_1 a} + b_2 e^{-\alpha_2 (a-\mu_2) - e^{-\lambda_2 (a-\mu_2)}} + c \qquad (3)$$

where $m_a^{i*}$ is the predicted age group rate. The first term on the right hand side represents a single negative exponential curve of the pre-labour force ages; the second term represents a left skewed unimodal curve of the labour force age range; and c is a constant which, with $b_1$ and $b_2$, determines the level of the schedule. The remaining parameters determine the shape of the schedule. Migrants from zone i to Northern Ireland are estimated as:

$$\hat{M}_a^{iNI} = m_a^{i*} \quad \hat{M}_*^{iNI} \qquad (4)$$

and Table 1 contains an example of the results obtained from using both methods to estimate flows from Tyne and Wear to Northern Ireland. The model-based method generates lower figures in the lower age groups and higher figures in the older age groups.

## 2.3 National Health Service re-registrations: annual movement data

The National Health Service maintains a Central Register (NHSCR) of changes of a patient's Family Practitioner Committee (FPC). Transfers occur when a patient registers with a new NHS doctor in an FPC other than that with which the patient was previously registered. The boundaries of FPC areas correspond with those of counties and metropolitan districts.

OPCS considers that this register data has a useful function as an indicator of internal migration in Great Britain in the absence of Census information. The register has been in operation since 1971, recording details of aggregate flows, but since 1975, OPCS has taken a 10% sample of patient re-registrations

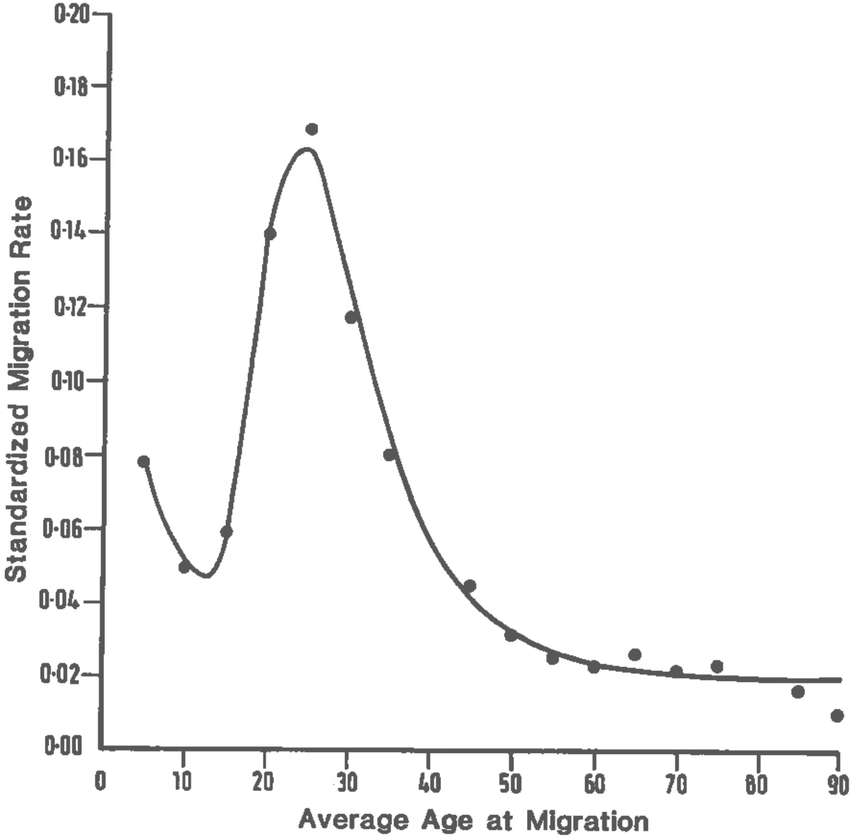


Figure 2. Model migration schedule for standardized outmigration rates from Tyne & Wear to other zones in Great Britain, 1966-71.

| Age Group at Census date | Average age at Migration | Standardized Migration Rate observed | Model Migration Rate Prediction | Flow to Northern Ireland from Tyne and Wear | |
|---|---|---|---|---|---|
| | | | | Model Estimates Equation (4) | Equation (2) Estimates |
| 5-9 | 5 | 0.0784 | 0.0780 | 14 | 19 |
| 10-14 | 10 | 0.0495 | 0.0512 | 9 | 11 |
| 15-19 | 15 | 0.0593 | 0.0568 | 10 | 13 |
| 20-24 | 20 | 0.1402 | 0.1435 | 26 | 33 |
| 25-29 | 25 | 0.1688 | 0.1626 | 30 | 30 |
| 30-34 | 30 | 0.1177 | 0.1226 | 22 | 19 |
| 35-39 | 35 | 0.0803 | 0.0830 | 15 | 13 |
| 40-44 | 40 | 0.0576 | 0.0566 | 10 | 10 |
| 45-49 | 45 | 0.0453 | 0.0409 | 7 | 9 |
| 50-54 | 50 | 0.0321 | 0.0317 | 6 | 6 |
| 55-59 | 55 | 0.0250 | 0.0265 | 5 | 5 |
| 60-64 | 60 | 0.0234 | 0.0235 | 4 | 4 |
| 65-69 | 65 | 0.0266 | 0.0218 | 4 | 4 |
| 70-74 | 70 | 0.0222 | 0.0208 | 4 | 3 |
| 75-79 | 75 | 0.0239 | 0.0203 | 4 | 2 |
| 80-84 | 80 | 0.0204 | 0.0199 | 4 | 1 |
| 85-89 | 85 | 0.0169 | 0.0198 | 4 | 1 |
| 90+ | 90 | 0.0110 | 0.0197 | 4 | 0 |

**Table 1.** **Model migration schedule estimates of age group flows from Tyne and Wear to Northern Ireland, 1966-71**

and produced tabulations for local planning authorities, which include some age/sex disaggregation. Quarterly statistics were produced until 1980 when local authorities requested tables for 12 month periods, thereby removing seasonal fluctuations. The primary unit data which consists of a series of records containing information about origin FPC, destination FPC, date of birth and sex, is aggregated to provide two computer summaries for each 12 month period. The first of these summaries contains the numbers of moves into and out of each FPC area disaggregated by sex and by age (the age groups are: all ages, 0-4, 5-9 ... 75+, not stated). The second contains total numbers moving into each FPC from every other FPC in the UK (including the Isle of Man). Region and metropolitan county flows are also available but the data in this table is not disaggregated by sex or age. The summary figures for recorded inter-regional moves in England and moves with Wales and Scotland are presented in OPCS monitors (OPCS MN series). Hitherto, NHSCR data has been used for national and regional analysis by Ogilvy (1979, 1980, 1982) and by Elias and Molho (1982) for labour-market modelling.

The NHSCR data has several limitations. There is no record of movers who don't register. Some individuals may remain with the same doctor despite moving into another county or metropolitan district. Wide variation exists in the period between a person moving and the subsequent re-registration. The propensity of a mover to re-register immediately depends on several factors, and OPCS estimate an average lag of about 3 months. When using the data it is important to recognize that, given this lag period, moves recorded between one September and the next are appropriate for mid-year to mid-year analysis. The figures are of course subject to sampling error and the quality of the registers tends to vary between urban and rural areas.

There are two major problems involved in aggregating the FPC area data to be consistent with the set of study zones defined in Figure 1. Only estimates of cross-border moves between Scotland and other zones in the rest of the UK are available from the register for England and Wales. Flows to and from Central Clydeside are not distinguished from flows to and from the Remainder of Scotland. The Scottish Central Register covers moves within Scotland and to and from England and Wales and the data is a 100% count rather than a sample. The other problem concerns the South East. Greater London is consistent for both zonal systems but the counties in the remainder of the South East do not aggregate into the Outer Metropolitan Area and the Outer South East and moves to and from these zones require estimation.

The procedure for obtaining complete sets of age-aggregated inter-zonal flows from the annual summaries is as follows: raw data for the FPC areas, metropolitan counties and regions comprising the set of study zones must be identified and a matrix consolidation program is used to generate the aggregated flows for each year. The Isle of Man is identified as a separate zone. Moves between Central Clydeside (and Scotland Remainder; Outer Metropolitan Area; Outer South East) and the 'other' zones in the UK are estimated by disaggregating the totals to and from Scotland (and Remainder of the South East) according to the proportions indicated by the 1966-71 Census flows. Moves from Central Clydeside (CC) to Tyne and Wear (TW) for example, are estimated as follows:

$$\hat{M}_*^{CC\ TW}(\text{NHSCR, Annual}) = \frac{M_*^{S\ TW}(\text{NHSCR, Annual})}{M_*^{S\ TW}(\text{Census, 1966-71})} M_*^{CC\ TW}(\text{Census, 1966-71}) \qquad (5)$$

Moves between the two Scottish zones and the two zones in the Remainder of the South East (RSE) are estimated using a similar method; moves from Central Clyde-side to the Outer Metropolitan Area (OMA) are estimated as:

$$\hat{M}_*^{CC\ OMA}(\text{NHSCR, Annual}) = \frac{M_*^{S\ RSE}(\text{NHSCR, Annual})}{M_*^{S\ RSE}(\text{Census, 1966-71})} M_*^{CC\ OMA}(\text{Census 1966-71}) \qquad (6)$$

The unknown moves remaining are those between Central Clydeside and Scotland Remainder (SR) and between Outer Metropolitan Area and Outer South East. The former are estimated on the basis of census proportions of total outmigration:

$$\hat{M}_*^{CC\ SR}(\text{NHSCR, Annual}) = \frac{M_*^{S*}(\text{NHSCR, Annual})}{M_*^{S*}(\text{Census, 1966-71})} M_*^{CC\ SR}(\text{Census, 1966-71}) \qquad (7)$$

One control total is available for moves between FPC areas in the remainder of the South East. Flows between the Outer South East and the Outer Metropolitan Area are estimated by disaggregating the total according to 1966-71 outmigration proportions, and the remaining moves are assumed to be internal to the two zones and divided between them on the basis of these outmigration proportions. Corresponding off-diagonal elements of the five relevant annual matrices can be summed to provide a set of five year data on aggregate moves during the period mid year 1976 to mid year 1981.

The procedure for obtaining sets of age-disaggregated inter-zonal flows from the annual summaries requires a similar initial identification of raw data to that used previously. Gross inmovement and outmovement totals are obtained for the sixteen age groups (0-4, 5-9 .... 70-74, 75+). The age-specific totals for Scotland require deconsolidation into totals for Central Clydeside and Scotland, Remainder whilst the Remainder of the South East totals are split between the Outer Metropolitan Area and the Outer South East. Deconsolidation of these totals is undertaken by applying the proportions obtained from the estimates of aggregate flows entering and leaving these zones. There remains the problem of estimating the age-specific inter-zonal flows, given the aggregate inter-zonal matrix and the age-specific outmove and inmove totals. This can be solved using an iterative balancing factor routine, but a more convenient formulation from a computational point of view is one in which the age-specific inter-zonal estimates ($M_a^{ij}$) are initially set to one, and subsequently adjusted in 3 stages as follows:

$$\hat{M}_a^{ij} = \hat{M}_a^{ij} \; (OD_*^{ij} \;/\; \sum_a M_a^{ij}) \tag{8}$$

$$\hat{M}_a^{ij} = \hat{M}_a^{ij} \; (D_a^{j} \;/\; \sum_i M_a^{ij}) \tag{9}$$

and

$$\hat{M}_a^{ij} = \hat{M}_a^{ij} \; (O_a^{i} \;/\; \sum_j M_a^{ij}) \tag{10}$$

where the given information is

$OD_*^{ij}$, aggregate moves by origin i and destination j,

$D_a^{j}$, moves by destination j and age group a,

and $O_a^{i}$, moves by origin i and age group a

The final estimates from equation (10) are reused in equation (8) and the model reiterates until the absolute difference between each estimate on successive iterations is below a pre-defined tolerance level (0.000001). In order to test alternative methods of projection in a later section, these age disaggregated estimates are assumed to represent 'observed flows'.

## 3. Characteristics of Internal Migration in the UK

### 3.1 The spatial pattern and age structure of five year migration, 1966-71

Analysis of migration behaviour is facilitated by the identification of three important dimensions: the overall level of mobility within the system, the spatial pattern of migration between zones in the system, and the age structure of migration.

During the 5 year period prior to the Census in 1971, nearly 4.1 million individuals (aged over 5 in 1971) were involved in migrating between the study area zones within the UK, whilst almost 13.8 millions moved within the same region. The inter-zonal total can be represented as a rate of 75 persons per thousand from the total usually-resident population at census date, 1966, and 30% of this migration involved persons aged between 20 and 29 at census date, 1971.

The spatial pattern of migration in aggregate net terms is characterized by gains to all the non-metropolitan zones in Great Britain and losses from the metropolitan zones (Figure 3), reflecting the process of decentralization from urban core areas to their surrounding hinterlands. Northern Ireland, for different reasons, has a negative net migration balance. Further evidence of the way in which decentralization dominates the migration distribution pattern is shown by the pairs of zones experiencing the most significant net gains or losses. The three largest net migration balances (in absolute terms) for each zone are presented in Table 2. The largest balance is the net loss of over ½ million migrants from Greater London to the Outer Metropolitan Area during the period. All the metropolitan counties apart from South Yorkshire lose primarily to their region remainders and correspondingly, the region remainders gain most migrants from their metropolitan cores. The North West Remainder gains more net migrants from Merseyside than from Greater Manchester, and Yorkshire and Humberside Remainder gains more from West Yorkshire than from South Yorkshire. A number of zones which are recipients of migrants from decentralizing metropolitan counties are also experiencing decentralization themselves. The Outer Metropolitan Area, which receives such a massive influx from Greater London, exports relatively large numbers to the Outer South East and the South West. Similarly the West Midlands Remainder gains from its metropolitan core yet loses to the South West and the Outer South East. Wales gains from Merseyside and Greater Manchester but loses to the South West.

Greater London and the Outer Metropolitan Area are key zones for migration activity within the system. The South West, East Anglia and Outer South East each gain primarily from Greater London and secondly, from the Outer Metropolitan Area. The East Midlands likewise gains from Greater London although, like the

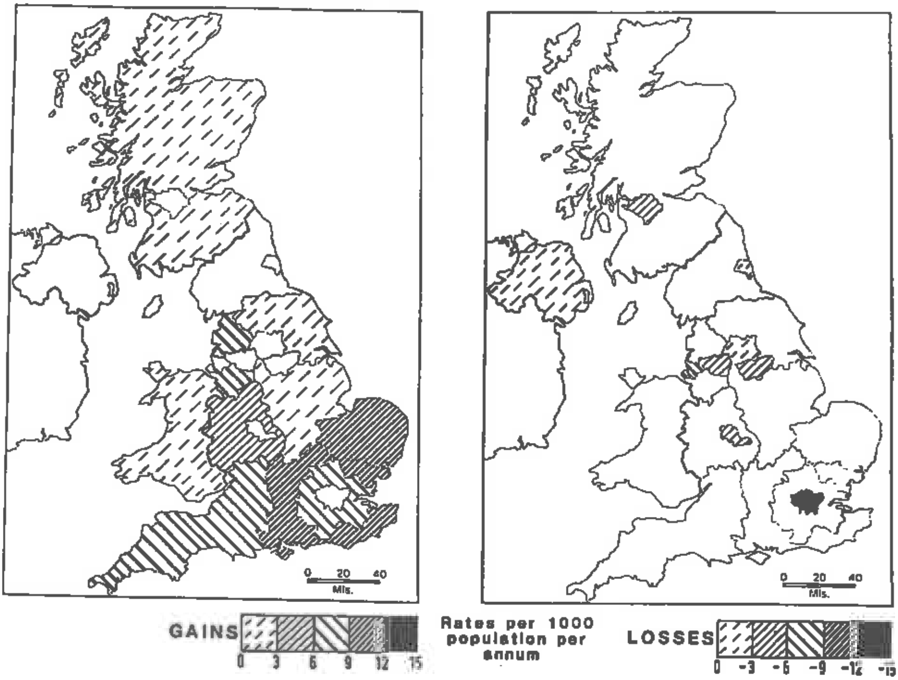


Figure 3. Annual aggregate net migration rates; gaining and losing zones, 1966-71

| ZONE | INTER-ZONAL NET MIGRATION BALANCE (00'S) | | | | | |
|---|---|---|---|---|---|---|
| | ZONE | BALANCE | ZONE | BALANCE | ZONE | BALANCE |
| NON-METROPOLITAN ZONES | | | | | | |
| OUTER METROPOLITAN AREA | GL | 2524 | OSE | -624 | SW | -260 |
| OUTER SOUTH EAST | GL | 1432 | OMA | 624 | GM | 49 |
| WEST MIDLANDS, REM. | WM | 619 | SW | -68 | OSE | -39 |
| NORTH WEST, REM. | M | 432 | GM | 267 | WY | 47 |
| SOUTH WEST | GL | 414 | OMA | 260 | WM | 131 |
| EAST ANGLIA | GL | 382 | OMA | 155 | EM | 40 |
| SCOTLAND, REM. | CC | 257 | OMA | -34 | GL | -34 |
| NORTH, REM. | TW | 146 | YHR | -38 | EM | -37 |
| EAST MIDLANDS | GL | 136 | SW | -86 | GM | 91 |
| YORKSHIRE AND HUMBS, REM. | WY | 93 | SY | 57 | NR | 38 |
| WALES | M | 67 | SW | -67 | GM | 58 |
| NORTHERN IRELAND | GL | -36 | SW | -21 | OMA | -19 |
| METROPOLITAN ZONES | | | | | | |
| SOUTH YORKSHIRE | EM | -68 | YHR | -57 | WY | -33 |
| WEST YORKSHIRE | YHR | -93 | NWR | -46 | SW | -36 |
| TYNE AND WEAR | NR | -146 | OMA | -34 | GL | -26 |
| CENTRAL CLYDESIDE | SR | -257 | GL | -45 | OMA | -37 |
| GREATER MANCHESTER | NWR | -267 | EM | -81 | SW | -80 |
| MERSEYSIDE | NWR | -432 | GM | -71 | W | -67 |
| WEST MIDLANDS | WMR | -620 | SW | -131 | EM | -79 |
| GREATER LONDON | OMA | -2524 | OSE | -1432 | SW | -414 |

Table 2. Three largest absolute net migration balances; study zones, 1966-71

Outer Metropolitan Area itself, loses to the South West. On the other hand there are zones in the North including Scotland Remainder, Tyne and Wear and Central Clydeside whose net outflows to Greater London and the Outer Metropolitan Area are of secondary or tertiary importance.

The spatial patterns of age-specific net migration conform with the aggregate pattern in all but a few cases. Metropolitan zones experience net losses in all age groups, apart from Greater London, which gains migrants in the 20-24 labour force age group (Table 3). The non-metropolitan regions gain migrants in all age groups, apart from the Outer Metropolitan Area, which experiences net losses of migrants aged 60-69 (retirement), and the four most peripheral regions which lose migrants in certain lower age groups. In particular there are substantial net losses of 7.5, 8 and 5.6 thousand migrants aged 20-24 from Scotland Remainder, Wales and the North Remainder respectively. Our estimates for Northern Ireland suggest net losses in the age groups up to 45-49, and marginal net gains in the older groups.

Net migration is the difference between gross inward and outward migration and the pattern of gross migration rates for 1966-71 (Figure 4) indicates that while metropolitan counties other than Greater London, form a group of zones with a relatively small range of gross rate values, non-metropolitan zones have rates which vary more widely, with the Outer Metropolitan Area and the Outer South East experiencing inmigration rates of 151 and 138 per thousand. The rate of inmigration for Greater London conforms with that of the other metropolitan zones, but the outmigration rate for this zone is much higher.

The third important dimension of migration is its age structure. The general shape of the migration rate age schedule has been shown to have universal application (Rogers, Raquillet and Castro, 1978) with variations identified according to the type and level of migration, the latter being dependent upon the nature of the zonal system of interest or the average distance over which migration occurs between or within zones. The age schedule of inter-zonal migration for our system is illustrated in Figure 5 and the profiles for total, intra-zonal and external migration are included for comparison. The initial decline in the propensity to migrate in all schedules is followed by an increase until the so-called labour force peak during age group 25-29 (average age 25), and subsequent decline thereafter, interrupted only by the retirement peak which occurs between the ages of 60 and 69. The rate of migration within zones is higher than the inter-zonal rate at all ages but two features distinguish the shape of the two schedules. Firstly, whereas intra-zonal migrants in their late teens have lower migration propensities than those in the preceding age group, inter-zonal migrants aged 15-19 have slightly higher propensities than those aged 10-14, as the labour force component of inter-zonal migration begins to become apparent. Secondly, the retirement peak at age group 65-69 is more pronounced for inter-zonal migration than for intra-zonal migration where retirement causes only a temporary

| | AVERAGE AGE AT MIGRATION, 1966-71 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZONE | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75+ |
| NON-METROPOLITAN ZONES | | | | | NET MIGRATION BALANCE (00'S) | | | | | | | | | | |
| OSE | 161 | 130 | 134 | 213 | 252 | 160 | 121 | 125 | 117 | 119 | 164 | 240 | 270 | 109 | 70 |
| OMA | 196 | 94 | 55 | 209 | 475 | 261 | 150 | 74 | 84 | 64 | 32 | -23 | -15 | 29 | 65 |
| SW | 84 | 69 | 81 | 61 | 63 | 59 | 67 | 64 | 77 | 87 | 128 | 182 | 189 | 71 | 52 |
| NWR | 100 | 75 | 34 | 17 | 125 | 95 | 61 | 56 | 54 | 47 | 35 | 42 | 38 | 18 | 12 |
| EA | 74 | 51 | 39 | 67 | 82 | 65 | 42 | 44 | 32 | 35 | 44 | 63 | 66 | 22 | 15 |
| WMR | 50 | 28 | 30 | 72 | 169 | 58 | 39 | 26 | 23 | 18 | 14 | 19 | 14 | 6 | 10 |
| EM | 62 | 34 | 2 | 56 | 99 | 51 | 38 | 30 | 18 | 10 | 11 | 3 | 10 | 12 | 13 |
| YHR | 14 | 9 | 19 | -35 | -3 | 8 | 12 | 17 | 10 | 7 | 11 | 28 | 25 | 13 | 9 |
| SR | 29 | 24 | -29 | -75 | 2 | 22 | 18 | 8 | 3 | 17 | 20 | 28 | 30 | 13 | 5 |
| W | 4 | 83 | -24 | -80 | -12 | 18 | 7 | 2 | 18 | 15 | 27 | 37 | 39 | 9 | -1 |
| NR | 8 | -2 | -33 | -56 | 22 | 15 | 9 | 6 | 8 | 0 | 5 | 5 | 3 | 5 | 0 |
| NI | -9 | -117 | -18 | -45 | -23 | -6 | -4 | -1 | -1 | 2 | 2 | 5 | 5 | 2 | 2 |
| METROPOLITAN ZONES | | | | | | | | | | | | | | | |
| WY | -6 | -3 | -21 | -37 | -23 | -10 | -12 | -5 | -11 | -6 | -9 | -18 | -22 | -9 | -5 |
| SY | -31 | -23 | -22 | -41 | -43 | -26 | -25 | -31 | -13 | -15 | -5 | -15 | -10 | -3 | -5 |
| TW | -32 | -22 | -31 | -66 | -65 | -36 | -24 | -20 | -21 | -8 | -8 | -5 | -8 | -4 | -10 |
| GM | -42 | -28 | -29 | -14 | -16 | -30 | -30 | -32 | -42 | -36 | -44 | -53 | -52 | -22 | -16 |
| CC | -54 | -54 | -40 | -81 | -68 | -45 | -30 | -28 | -22 | -20 | -22 | -23 | -24 | -10 | -13 |
| M | -68 | -51 | -44 | -133 | -132 | -65 | -35 | -34 | -27 | -23 | -23 | -24 | -22 | -11 | -9 |
| WM | -68 | -49 | -46 | -108 | -194 | -79 | -55 | -48 | -48 | -48 | -50 | -62 | -63 | -24 | -15 |
| GL | -472 | -280 | -57 | 77 | -711 | -515 | -346 | -253 | -259 | -268 | -332 | -429 | -476 | -225 | -180 |

Table 3. Age-specific net migration balances; study zones, 1966-71

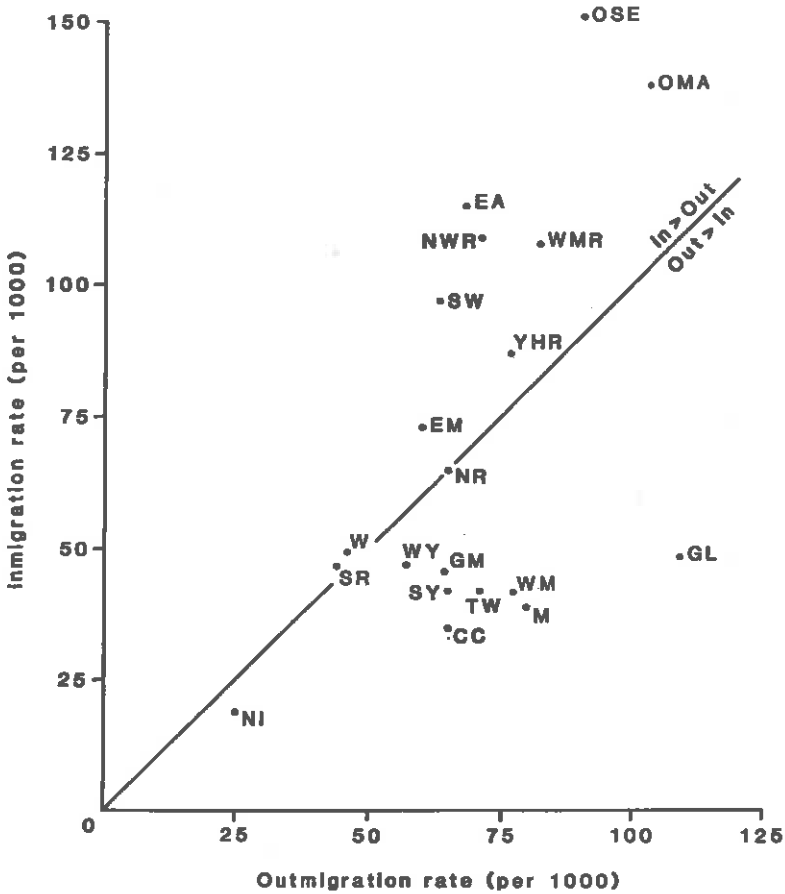


Figure 4. Gross rates of aggregate out- and immigration; study zones, 1966-71

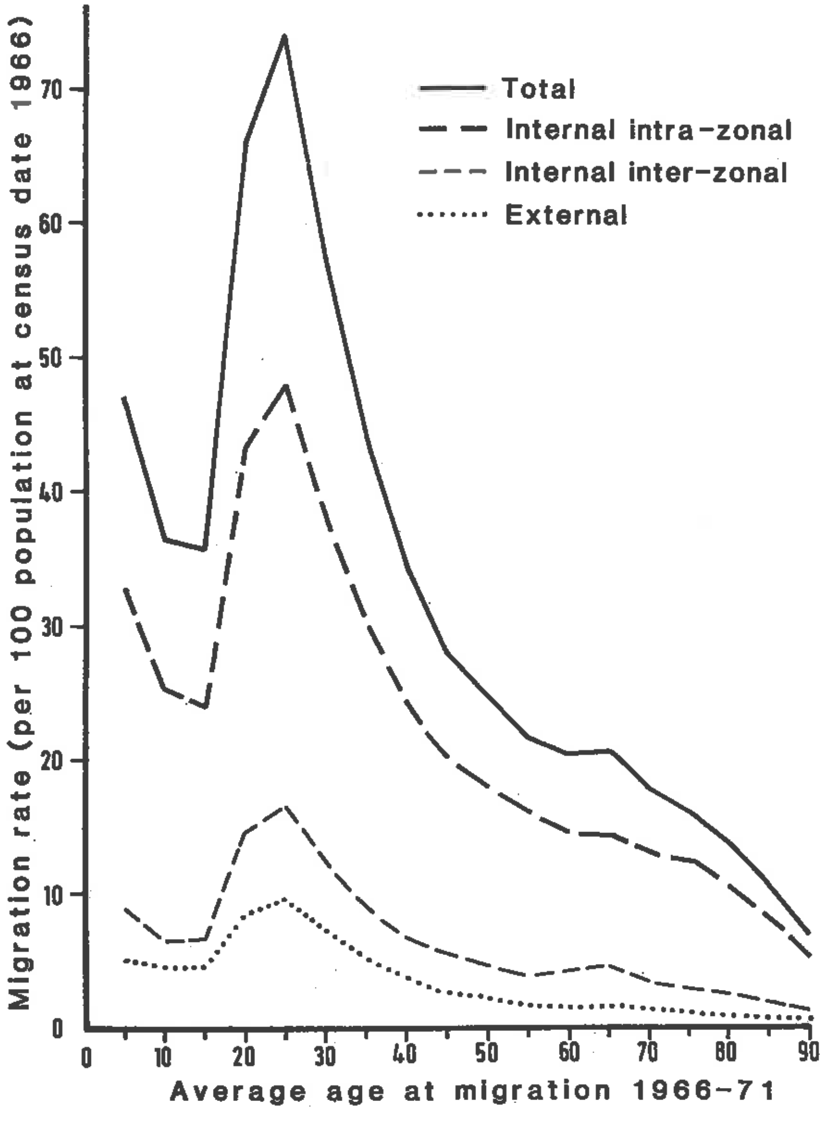


Figure 5. Age schedules for total, inter-zonal, intra-zonal and external migration rates, 1966-71

levelling out of the schedule.

The statistics presented in Table 4 provide further details of the extent to which migration by age group varies as a percentage of age group population. In summary, 25.3% of the population aged over 5 moved within the same zone during 1966-71, and 7.5% moved between different zones within the UK. Broad age group categorization shows that 18.6% of total migration involved children aged 5-14 (16.4% of total population), 33.6% of migration involved young adults of 15-29 years (21.6% of population), 35.5% was persons aged 30-59 (37.7% of population) and only 12.3% involved persons aged over 60 (24.4% of total population). At the most popular age for migration (between 25 and 29 at census date, 1971), nearly 65% of the population moved usual residence. The preceding discussion suggests that age structure should be taken into account when comparing migration rates between zones. It might be argued that high rates of migration occur because of higher proportions of young people in the population rather than a higher propensity for migration in the population as a whole. One method of comparison which allows for age structure is the calculation of gross migraproduction rates ($gmr^i$) defined as the sum of age-specific migration rates for each zone and calculated as:

$$gmr^i = \sum_a \left( \sum_i \sum_j M_a^{ij} / P_a^i \right) \qquad (11)$$

where $M_a^{ij}$ represents the flow of migrants in age group a between zone i and zone j

and $P_a^i$ represents the population of zone i in age group a

However, age structure differences are not an important influence on the spatial variation in migration propensity. The majority of non-metropolitan zones have relatively high inter-zonal gross migraproduction rates while the rates for metropolitan zones, with the exception of Greater London, are relatively low.

### 3.2 Changes in the pattern of five year migration between 1966-71 and 1976-81

The 1981 census of population did not include a five year migration question. In the absence of transition data for 1976-81, annual NHSCR moves data can be aggregated and used to examine whether there have been any significant changes in the spatial distribution patterns of migration in these two five year periods. Direct comparisons of levels, flows and rates are not appropriate because of the conceptual differences in the two measures of migration which have been discussed in Section 2. One feasible method of comparison is through examination of the migration to and from each zone as a proportion of total migration. Shifts in the immigration and outmigration proportions between the two five year periods (Table 5) indicate that while the overall pattern of movement in 1976-81 has remained similar to that in 1966-71, metropolitan zones have increased their proportional shares of immigration and, except for West Yorkshire, have reduced their proportional shares of outmigration.

| END OF PERIOD AGE GROUP | START OF PERIOD POPULATION | INTER-ZONAL MIGRATION | | | INTRA-ZONAL MIGRATION | | |
|---|---|---|---|---|---|---|---|
| | | TOTAL FLOWS | % OF AGE GROUP POP'N | % OF TOTAL MIGRATION | TOTAL FLOWS | % OF AGE GROUP POP'N | % OF TOTAL MIGRATION |
| 5-9 | 4706437 | 425451 | 9.0 | 10.4 | 1550226 | 32.9 | 11.3 |
| 10-14 | 4214364 | 280633 | 6.7 | 6.9 | 1066069 | 25.3 | 7.7 |
| 15-19 | 3841613 | 258376 | 6.7 | 6.3 | 922876 | 24.0 | 6.7 |
| 20-24 | 4278018 | 624817 | 14.6 | 15.3 | 1850601 | 43.3 | 13.4 |
| 25-29 | 3619076 | 603553 | 16.7 | 14.8 | 1739030 | 48.1 | 12.6 |
| 30-34 | 3280478 | 401962 | 12.3 | 9.8 | 1245765 | 38.0 | 9.1 |
| 35-39 | 3225990 | 289096 | 9.0 | 7.1 | 965782 | 29.9 | 7.0 |
| 40-44 | 3394772 | 229465 | 6.8 | 5.6 | 812024 | 23.9 | 5.9 |
| 45-49 | 3646693 | 194933 | 5.3 | 4.8 | 727989 | 20.0 | 5.3 |
| 50-54 | 3405740 | 156370 | 4.6 | 3.8 | 606947 | 17.8 | 4.4 |
| 55-59 | 3573392 | 142383 | 4.0 | 3.5 | 564978 | 15.8 | 4.1 |
| 60-64 | 3488943 | 146093 | 4.2 | 3.6 | 510742 | 14.6 | 3.7 |
| 65-69 | 3095606 | 144668 | 4.7 | 3.5 | 443909 | 14.3 | 3.2 |
| 70-74 | 2469119 | 82679 | 3.3 | 2.0 | 318178 | 12.9 | 2.3 |
| 75-79 | 1828844 | 52082 | 2.8 | 1.3 | 224950 | 12.3 | 1.6 |
| 80-84 | 1265550 | 31426 | 2.5 | 0.8 | 133240 | 10.5 | 1.0 |
| 85-89 | 722811 | 14127 | 2.0 | 0.3 | 58816 | 8.1 | 0.4 |
| 90+ | 392554 | 5105 | 1.3 | 0.1 | 20553 | 5.2 | 0.1 |
| OVER 5 | 54450000 | 4083219 | 7.5 | 100.0 | 13762715 | 25.3 | 100.0 |

**Table 4.** Age-specific inter- and intra-zonal migration totals and proportions, 1966-71

| ZONES | INMIGRATION PROPORTIONS % 1966-71 MIGRANTS (A) | % 1976-81 MOVES (B) | % CHANGE (B)-(A) | OUTMIGRATION PROPORTIONS % 1966-71 MIGRANTS (C) | % 1976-81 MOVES (D) | % CHANGE (D)-(C) |
|---|---|---|---|---|---|---|
| NON-METROPOLITAN ZONES | | | | | | |
| OMA | 16.83 | 14.39 | -2.44 | 12.54 | 14.56 | 2.02 |
| OSE | 14.47 | 13.74 | -0.73 | 8.63 | 9.89 | 1.26 |
| NWR | 5.61 | 4.82 | -0.79 | 3.63 | 4.44 | 0.81 |
| SW | 9.34 | 8.93 | -0.41 | 6.07 | 6.92 | 0.85 |
| WMR | 5.80 | 5.45 | -0.35 | 4.39 | 4.67 | 0.28 |
| YHR | 3.06 | 2.99 | -0.07 | 2.71 | 2.72 | 0.01 |
| NR | 3.00 | 2.93 | -0.07 | 3.01 | 3.01 | 0.00 |
| NI | 0.68 | 0.62 | -0.06 | 0.93 | 0.89 | -0.04 |
| EA | 4.41 | 4.48 | 0.07 | 2.60 | 3.28 | 0.68 |
| EM | 6.21 | 6.30 | 0.09 | 5.10 | 5.68 | 0.58 |
| SR | 3.98 | 4.28 | 0.30 | 3.69 | 3.65 | -0.04 |
| W | 3.20 | 3.66 | 0.46 | 3.03 | 3.33 | 0.30 |
| METROPOLITAN ZONES | | | | | | |
| CC | 1.53 | 1.64 | 0.11 | 2.83 | 2.78 | -0.05 |
| GM | 3.08 | 3.21 | 0.13 | 4.27 | 4.11 | -0.16 |
| TW | 1.26 | 1.51 | 0.25 | 2.14 | 1.88 | -0.26 |
| M | 1.62 | 1.90 | 0.28 | 3.34 | 2.70 | -0.64 |
| WY | 2.38 | 2.71 | 0.33 | 2.87 | 3.13 | 0.26 |
| SY | 1.34 | 1.67 | 0.33 | 2.10 | 1.76 | -0.34 |
| WM | 2.82 | 3.27 | 0.45 | 5.17 | 4.87 | -0.30 |
| GL | 9.39 | 11.51 | 2.12 | 20.97 | 15.77 | -5.20 |

Table 5. Inmigration and outmigration proportions; study zones, 1966-71 and 1976-81

Many of the non-metropolitan zones, on the other hand, have reduced shares of immigration and larger shares of outmigration. These shifts in proportions suggest a marginal deceleration in the process of decentralization. The most significant change is the reduction in Greater London's proportion of total outmigration by 5.2%, and the corresponding increase of 2.1% in its proportion of total immigration. As a result of this shift, the proportion of movements entering the Remainder of the South East region has declined by 3.2% whereas the proportion moving out has increased by a similar amount. Four non-metropolitan zones (EA, EM, SR and W) increase their share of immigration whilst two (NI and SR) show a reduced proportion of total outmigration.

A second method of assessing changes in the migration distributions for the two periods is to examine the hierarchy (Table 6) which appear when zones are ordered according to the number of positive net inflows (Rees and Stillwell, 1982). Non-metropolitan zones tend to appear higher up the hierarchy than metropolitan zones, except for Greater London which gains from the 11 zones below it in the 1966-71 period, and loses to the 8 zones above it. The South West, East Anglia, Outer South East and East Midlands are the top four zones in the hierarchies for both periods, whilst Northern Ireland, Central Clydeside, Tyne and Wear and Merseyside occupy the bottom four positions. Several of the intermediate zones in the hierarchy do not experience the same stability. The North West Remainder, ranked fifth in 1966-71 and receiving a net gain of movers from 15 other zones, drops to rank 12 in 1976-81, and gains from only 9 zones. On the other hand, the metropolitan county of South Yorkshire moves up the hierarchy by five places, losing migrants in net terms to only 9 zones in 1976-81 compared with 15 zones in the previous period. Wales, Greater London and Scotland Remainder move slightly up the hierarchy while the Outer Metropolitan Area and Greater Manchester move slightly downwards.

### 3.3 The propensity to migrate over distance

The observation that each zone interacts with every other zone but that more migration takes place between near zones than distant zones is the foundation upon which gravity models of migration are based. The negative relationship between migration interaction and distance is one of the laws of migration (Ravenstein, 1885) and the precise nature of the relationship has been investigated widely in the literature by Masser (1970) and Weeden (1973) in the UK for example, and by Somermeijer (1971) in the Netherlands. Traditional gravity models, calibrated using log linear regression methods, have been rewritten by Wilson (1974) as spatial interaction models, derived by entropy-maximizing methods, which incorporate additional knowledge in the form of constraints. A doubly constrained spatial

| | 1966 - 71 | | | | | 1976 - 81 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NUMBER OF INFLOWS | | NUMBER OF OUTFLOWS | | | NUMBER OF INFLOWS | | NUMBER OF OUTFLOWS | |
| RANK | ZONE | EXP | OBS | EXP | OBS | ZONE | EXP | OBS | EXP | OBS |
| 1 | SW | 19 | 19 | 0 | 0 | SW | 19 | 19 | 0 | 0 |
| 2 | EA | 18 | 18 | 1 | 1 | EA | 18 | 18 | 1 | 1 |
| 3 | OSE | 17 | 16 | 2 | 3 | OSE | 17 | 16 | 2 | 3 |
| 4 | EM | 16 | 15 | 3 | 4 | EM | 16 | 15 | 3 | 4 |
| 5 | NWR | 15 | 15 | 4 | 4 | W | 15 | 14 | 4 | 5 |
| 6 | OMA | 14 | 14 | 5 | 5 | GL | 14 | 13 | 5 | 6 |
| 7 | W | 13 | 12 | 6 | 7 | SR | 13 | 12 | 6 | 7 |
| 8 | WMR | 12 | 12 | 7 | 7 | OMA | 12 | 12 | 7 | 7 |
| 9 | GL | 11 | 11 | 8 | 8 | WMR | 11 | 12 | 8 | 7 |
| 10 | YHR | 10 | 10 | 9 | 9 | YHR | 10 | 11 | 9 | 8 |
| 11 | SR | 9 | 8 | 10 | 11 | SY | 9 | 10 | 10 | 9 |
| 12 | NR | 8 | 8 | 11 | 11 | NWR | 8 | 9 | 11 | 10 |
| 13 | GM | 7 | 8 | 12 | 11 | NR | 7 | 7 | 12 | 12 |
| 14 | WY | 6 | 7 | 13 | 12 | WY | 6 | 7 | 13 | 12 |
| 15 | WM | 5 | 6 | 14 | 13 | GM | 5 | 5 | 14 | 14 |
| 16 | SY | 4 | 4 | 15 | 15 | WM | 4 | 4 | 15 | 15 |
| 17 | M | 3 | 4 | 16 | 15 | TW | 3 | 3 | 16 | 16 |
| 18 | TW | 2 | 2 | 17 | 17 | M | 2 | 2 | 17 | 17 |
| 19 | CC | 1 | 1 | 18 | 18 | CC | 1 | 1 | 18 | 18 |
| 20 | NI | 0 | 0 | 19 | 19 | NI | 0 | 0 | 19 | 19 |

EXP = NUMBER OF FLOWS EXPECTED IF HIERARCHICAL ORDERING IS PERFECT
OBS = NUMBER OF OBSERVED FLOWS

Table 6. Zones arranged in hierarchical order according to number of net inflows, 1966-71 and 1976-81

interaction model of migration takes the form:

$$M^{ij} = A^i B^j O^i D^j f(d^{ij}) \tag{12}$$

where $O^i$ is the total outmigration from zone i

$D^j$ is the total immigration to zone j, and

$f(d^{ij})$ is a distance function.

The other terms on the right hand side of the equation are balancing factors defined as:

$$A^i = 1/ \sum_j B^j D^j f(d^{ij}) \tag{13}$$

and $$B^j = 1/ \sum_i A^i O^i f(d^{ij}) \tag{14}$$

which are used to ensure that the constraints:

$$O^i = \sum_j M^{ij} \tag{15}$$

and $$D^j = \sum_i M^{ij} \tag{16}$$

are satisfied. Distance is measured as road mileage between the zones and historical tests suggest that the negative power decay function $(d^{ij-\beta})$ is preferable to the negative exponential form. The optimum decay parameter, $\beta$, is estimated using a Newton Paphson iterative search routine and in its general form, can be interpreted as a measure of the general propensity to migrate over distance. Higher beta values mean that the friction of distance effect is greater, or that migrants show a greater rigidity towards moving over distance. The same distance matrix was used to fit a number of doubly constrained spatial interaction models to the transition data for 1966-71 and to the movement data for 1976-81. The aggregate flows model for 1966-71 has a generalized decay parameter value of 1.15 associated with an observed mean migration distance for our zone system of 82.6 miles. In comparison, the model for aggregate moves, 1976-81, has a $\beta$ value of 1.08 and the mean movement distance is 86.6 miles.

Spatial variation in the propensity to move into and away from individual zones in the system can be examined by calibrating origin-and destination-specific parameters. Whereas the pattern of variation in mean out- or inmigration lengths reflects the relative location of each zone to all other zones, accessibility does not necessarily determine the propensity to migrate over distance. Origin-specific decay parameters for the two five year periods are illustrated in Figure 6. For 1966-71 the West Midlands is the most accessible of all the

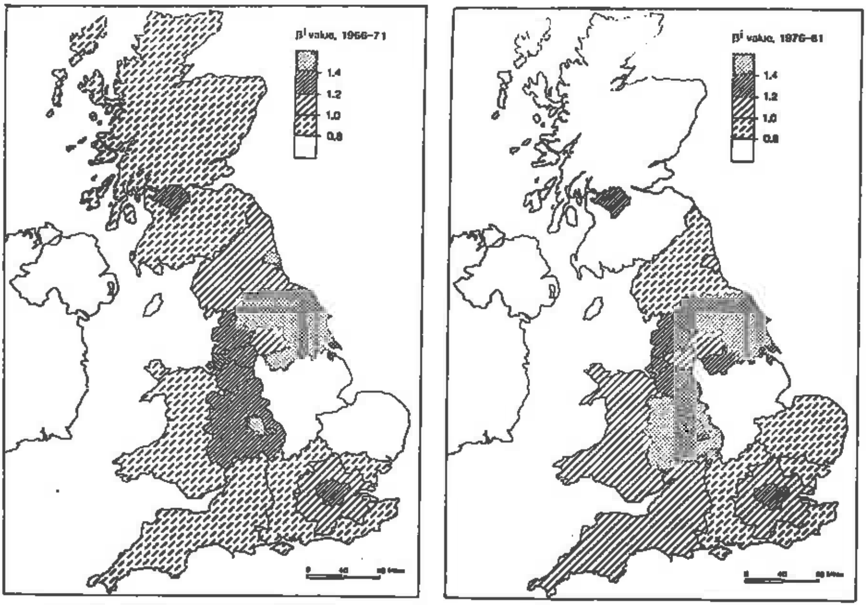


Figure 6. The spatial pattern of origin-specific distance decay parameters; 1966-71 and 1976-81

zones and has the highest $\beta^i$ value of 2.07 in contrast to Northern Ireland, the least accessible zone whose $\beta^i$ value is 0.14, but there is no consistent relationship between $\beta^i$ and mean migration distance since Greater London, Tyne and Wear and Central Clydeside all have similar decay parameter values, but very different mean outmigration distances of 68.7, 117.4 and 149.4 miles respectively. On the other hand, Merseyside and West Yorkshire, which have identical mean migration lengths, have dissimilar $\beta^i$ values of 1.63 and 1.16. The spatial pattern which emerges from Figure 6 is one which shows that outmigrants from metropolitan zones tend to be more influenced by distance than migrants from non-metropolitan zones, although there are exceptions. West Yorkshire in 1966-71, and in 1976-81 together with Greater Manchester, have low beta values compared with other metropolitan counties, whereas the remainders of Yorkshire and Humberside and the West Midlands have relatively high decay parameters.

The variation in immigration propensities is represented by the destination-specific parameters and Figure 7 illustrates that for metropolitan zones, the friction of distance influences outmigration during 1966-71 more than immigration, particularly in the cases of Greater London, Merseyside and West Midlands. Destination-specific parameters for non-metropolitan zones are higher than origin-specific parameters indicating the greater effect of distance on migrants into these zones than on migrants out of them. The exception is Northern Ireland, whose $\beta^i$ value is low and whose $\beta^j$ value is positive, suggesting that migration increases as the zone of origin becomes further away! If we compare the zone-specific parameters and the mean migration distances for the two time periods, the patterns of change illustrated in Figure 8 are different. The zones for which the influence of distance on outmigration increases are the non-metropolitan zones in the South of the country. $\beta^i$ parameter values decline for the metropolitan zones and for the Northern non-metropolitan regions. There are corresponding increases in the average distance migrated for these zones and decreases for the former set. Immigration into only four of the zones (West Midlands, Merseyside, East Midlands and Northern Ireland) becomes more affected by distance from the first period to the second and the average distance increases for migration into the majority of zones. Migration flows disaggregated into five year age groups can be modelled using a similar doubly constrained spatial interaction formulation:

$$M_a^{ij} = A_a^i \; B_a^j \; O_a^i \; D_a^j \; d^{ij - \beta_a^*} \qquad (17)$$

in which a generalized age-specific decay parameter is calibrated. Figure 9 illustrates the variation in the age-specific parameters for the transition data for 1966-71 and for the estimated movement data for 1976-81. The results of modelling the transition data indicate that migrants aged 15-19 at the end of the

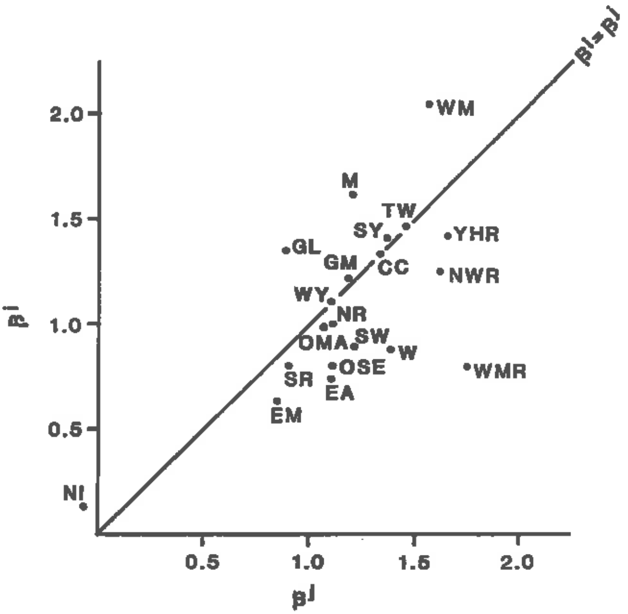


Figure 7. Origin and destination-specific decay parameters for aggregate inter-zonal flows, 1966-71

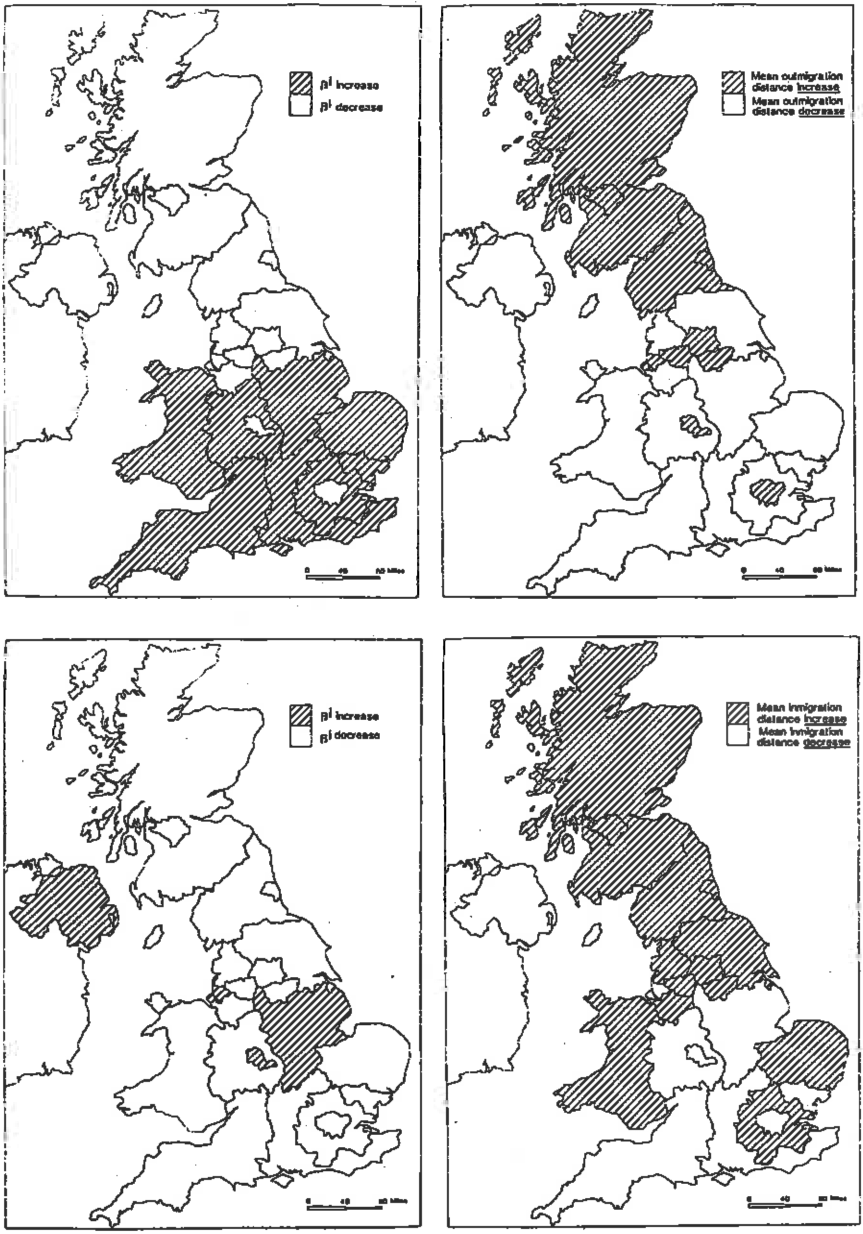


Figure 8. Changes in origin- and destination-specific decay parameters and out- and inmigration distances between 1966-71 and 1976-81

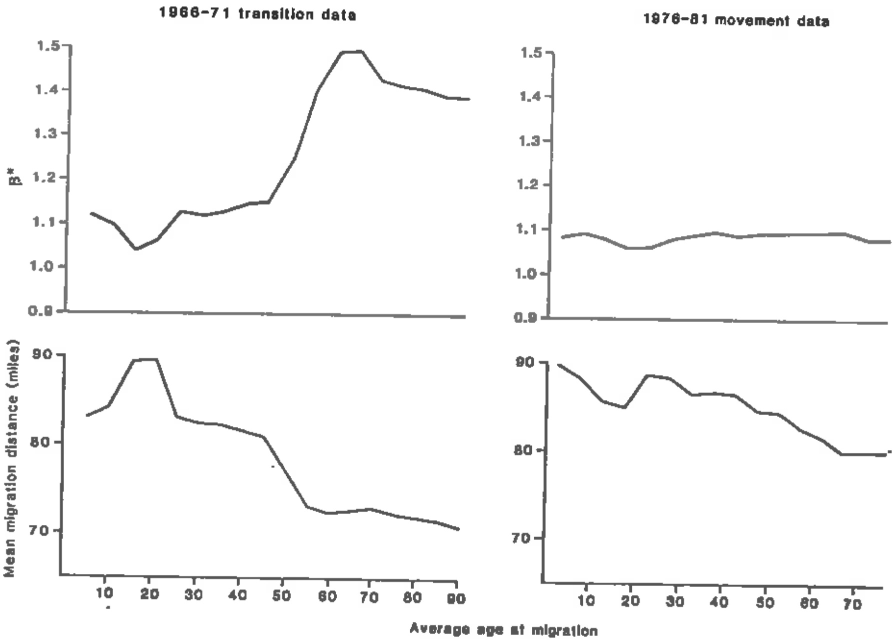


Figure 9. Age-specific distance decay parameters and mean migration distances; 1966-71 and 1976-81

period (average age at migration of 15) have the lowest of the $\beta_a^*$ values and that propensities to migrate over distance generally decline up to retirement age with corresponding differences in the mean distances of migration. This pattern of age differentials is not so pronounced when the movement data is modelled. The age group definition is different for this type of data and the lack of variation is not unexpected since the distribution of flows for each age group being modelled has been estimated using the same aggregate flows matrix.

### 3.4 Trends in annual movement data since 1976

The lack of time series data on migration within the UK has had a limiting effect on historical and forecasting analysis. Annual NHSCR data, despite its weaknesses, does provide a welcome source of information on movement in more recent years, and this section aims to illustrate that while levels of mobility have declined since 1976, the patterns of gross and inter-zonal mobility have remained relatively stable.

The number of transfers between metropolitan and non-metropolitan study zones in the 12 months ending mid year 1982 totalled 1236 thousand; compared with 1469 thousand moves in the 12 months ending mid year 1976. This decline of nearly 16% is consistent with the decreasing level of mobility identified by Ogilvy (1979) that has occurred in the UK since 1973. Figure 10 indicates that the reduction in total moves has not been a consistent reduction each year, and that the totals for 1977-78 and 1980-81 were both higher than the number of moves in the previous year, yet over the 7 year time series there is clearly a downward trend. Figure 10 is a cumulative frequency diagram, illustrating the amount of movement in each of four broad age groups. The level of migration in the 0-14 age group fell from 328 thousand in 1976 to 235 thousand in 1982, a decline of over 28% from the 1976 level. Declines of 14%, 10% and 8% were experienced in the 15-29, 30-59 and over 60 age groups. There has been some readjustment in the proportional shares of total movement in each of the five year age groups (Table 7). The proportion of movement in the three lowest age groups and in the 25-29, 45-49 and 50-54 age groups has declined, while the proportions in the remaining groups have either remained the same or have increased.

The decline in the level of mobility is a trend which appears to be consistent across virtually all the regions (Figure 11), regardless of the differences in the levels of aggregate movement involved. But to what extent has the pattern of movement changed since 1976? The stability of the spatial structure of migration can be examined if we distinguish the generation component from the distribution component. The generation component can be represented by the

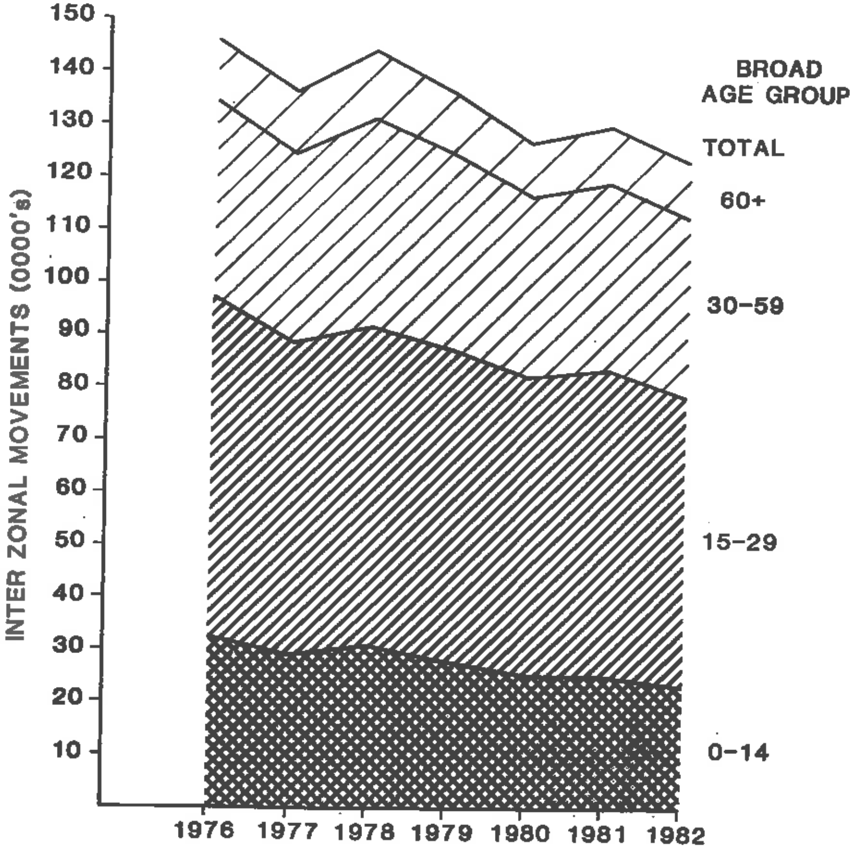


Figure 10. Cumulative age-group movement levels for single years ending mid-year 1976 to mid-year 1982

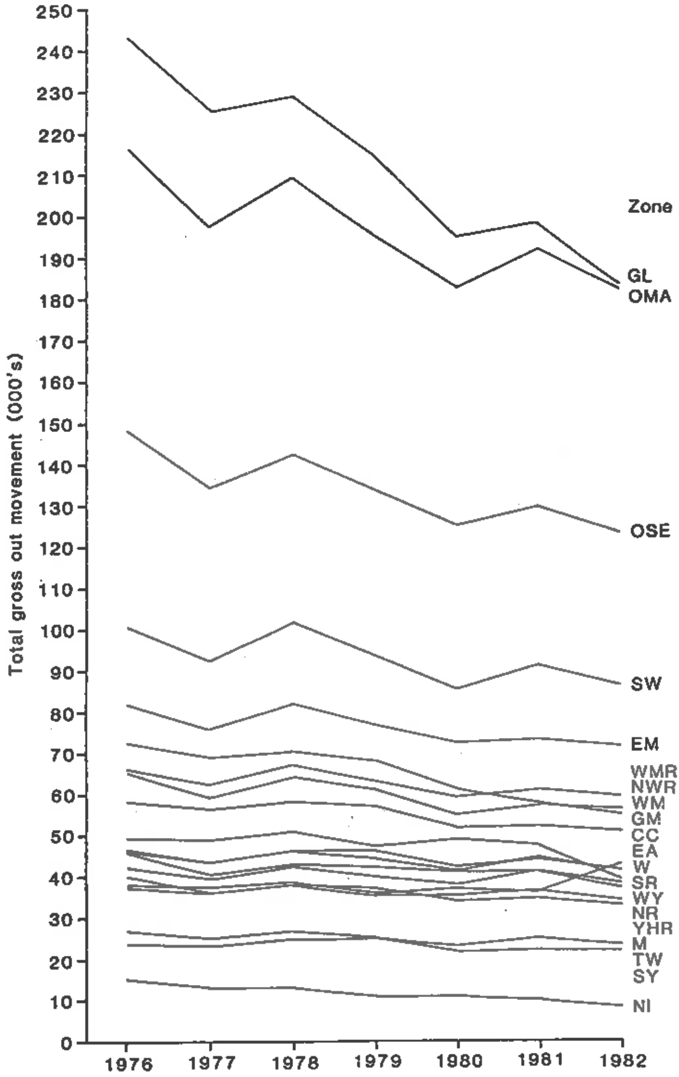


Figure 11. Levels of aggregate gross outmovement; study zones, 1975-76 to 1981-82

proportion of total moves leaving each origin zone, given the total level of mobility, and Figure 12 presents the outmove probabilities in percentage terms for each of the 20 study zones. While levels of outmigration have declined over time and are not directly comparable between zones of different size, outmove proportions are comparable and show a marked stability over time. The Outer Metropolitan Area and the Outer South East are the largest movement generating zones and have stable outmove probability schedules. Greater London is the zone for which there is most fluctuation in the outmove proportion, due largely to an increase from 11.4% in 1979-80 to 12.4% in 1980-81. The role of the South West as a generating zone is illustrated by the graph and this zone maintains a stable schedule of around 9%. These four zones account for almost half the total outmoves occurring in the system. A group of non-metropolitan zones including the East Midlands; West Midlands Remainder; Scotland Remainder; North West Remainder; and East Anglia have proportions between 4 and 7% whilst the remaining zones have proportions below 4%. The metropolitan counties of Merseyside, Tyne and Wear, South Yorkshire and Central Clydeside each account for only between 1 and 2% of total outmoves and Northern Ireland accounts for less than 1%.

The second component of the spatial structure of migration is the distribution component which can be defined as the proportion of total moves from any one origin zone i which end up in destination zone j. The conclusion from a comparison of the distribution probabilities over the seven years is that the pattern of aggregate movement between zones has also remained stable. The proportions of total outmovement from Greater London to each of the other zones in each 12 month period are presented in Table 8 as an example of this stability for a zone which has a relatively unstable generation component. Outmovement from this zone is dominated by flows to the Outer Metropolitan Area, Outer South East and to a lesser extent to the South West, East Anglia, East Midlands, Wales and Scotland Remainder. Flows to any other zone account for less than 2% of total outmovement from Greater London. The probabilities do not suggest that any significant changes are occurring in the pattern of movement even though the level of outmovement has fallen by 24 % from 244 thousand moves in 1975-76 to 184 thousand in 1982-82.

The analysis of aggregate movement data has demonstrated stability in the spatial structure of migration for the system of metropolitan and non-metropolitan zones. Consequently, techniques of short term projection are preferred which are based upon the pattern of previous movement. Methods of modelling the historical effect are amongst those which are discussed in the next section.

| AGE GROUP | % OF TOTAL INTER - ZONAL MOVEMENT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| 0-4 | 8.8 | 8.3 | 8.1 | 7.7 | 7.6 | 7.6 | 7.5 |
| 5-9 | 7.4 | 7.3 | 7.3 | 6.9 | 6.6 | 6.1 | 5.7 |
| 10-14 | 6.1 | 6.2 | 6.1 | 6.1 | 6.1 | 5.8 | 5.8 |
| 15-19 | 11.2 | 11.5 | 11.2 | 11.6 | 11.9 | 12.1 | 12.5 |
| 20-24 | 17.8 | 17.6 | 17.0 | 17.7 | 18.5 | 18.9 | 18.8 |
| 25-29 | 15.0 | 14.3 | 13.9 | 14.0 | 14.0 | 13.9 | 13.5 |
| 30-34 | 8.4 | 9.3 | 9.9 | 10.3 | 10.2 | 10.2 | 9.6 |
| 35-39 | 5.2 | 5.2 | 5.3 | 5.5 | 5.6 | 5.6 | 6.2 |
| 40-44 | 3.6 | 3.7 | 3.9 | 3.7 | 3.5 | 3.6 | 3.7 |
| 45-49 | 3.0 | 3.0 | 3.1 | 2.9 | 2.8 | 2.8 | 2.9 |
| 50-54 | 2.8 | 2.7 | 2.8 | 2.5 | 2.5 | 2.4 | 2.5 |
| 55-59 | 2.4 | 2.4 | 2.8 | 2.7 | 2.5 | 2.4 | 2.4 |
| 60-64 | 2.5 | 2.6 | 2.5 | 2.2 | 2.2 | 2.4 | 2.6 |
| 65-69 | 2.2 | 2.3 | 2.5 | 2.3 | 2.2 | 2.2 | 2.2 |
| 70-74 | 1.4 | 1.5 | 1.5 | 1.5 | 1.5 | 1.6 | 1.6 |
| 75+ | 2.1 | 2.2 | 2.3 | 2.2 | 2.3 | 2.4 | 2.6 |
| TOTAL MOVES (000'S) | 1469 | 1366 | 1442 | 1362 | 1270 | 1303 | 1236 |

Table 7. Five year age group proportions of annual inter-zonal moves, 1976-1982

| DESTINATION ZONE | % OF TOTAL OUTMOVEMENT FROM GREATER LONDON | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
| OMA | 39.8 | 39.8 | 40.3 | 40.0 | 39.1 | 39.9 | 40.5 |
| OSE | 21.1 | 21.0 | 21.3 | 21.2 | 20.7 | 21.1 | 21.4 |
| SW | 9.2 | 9.4 | 9.8 | 9.2 | 9.5 | 9.4 | 8.9 |
| EA | 6.2 | 6.2 | 6.1 | 6.6 | 6.4 | 5.8 | 5.8 |
| EM | 4.8 | 4.8 | 4.6 | 4.8 | 5.1 | 4.6 | 4.6 |
| W | 2.4 | 2.7 | 2.5 | 2.7 | 2.6 | 2.7 | 2.5 |
| SR | 2.4 | 2.0 | 2.0 | 1.9 | 2.2 | 2.2 | 2.1 |
| WMR | 1.8 | 1.9 | 1.8 | 1.7 | 1.8 | 1.7 | 1.8 |
| WM | 1.6 | 1.8 | 1.6 | 1.8 | 1.8 | 1.7 | 1.9 |
| WY | 1.4 | 1.3 | 1.2 | 1.2 | 1.3 | 1.5 | 1.4 |
| GM | 1.4 | 1.6 | 1.5 | 1.5 | 1.7 | 1.7 | 1.7 |
| NWR | 1.4 | 1.6 | 1.5 | 1.5 | 1.4 | 1.6 | 1.3 |
| NR | 1.2 | 1.1 | 1.1 | 1.1 | 1.2 | 1.2 | 1.1 |
| YHR | 1.2 | 1.1 | 1.2 | 1.0 | 1.1 | 1.3 | 1.1 |
| CC | 1.0 | 0.8 | 0.8 | 0.7 | 0.9 | 0.9 | 0.8 |
| TW | 0.9 | 0.8 | 0.6 | 0.8 | 0.9 | 0.7 | 0.9 |
| M | 0.9 | 0.9 | 0.7 | 0.8 | 0.9 | 0.9 | 0.8 |
| SY | 0.7 | 0.8 | 0.6 | 0.6 | 0.8 | 0.9 | 0.8 |
| NI | 0.6 | 0.5 | 0.7 | 0.7 | 0.7 | 0.4 | 0.6 |
| TOTAL OUT MOVES (000'S) FROM GL | 244 | 226 | 229 | 215 | 195 | 198 | 184 |

Table 8. Outmove proportions from Greater London to other zones, 1976-76 to 1981-82.

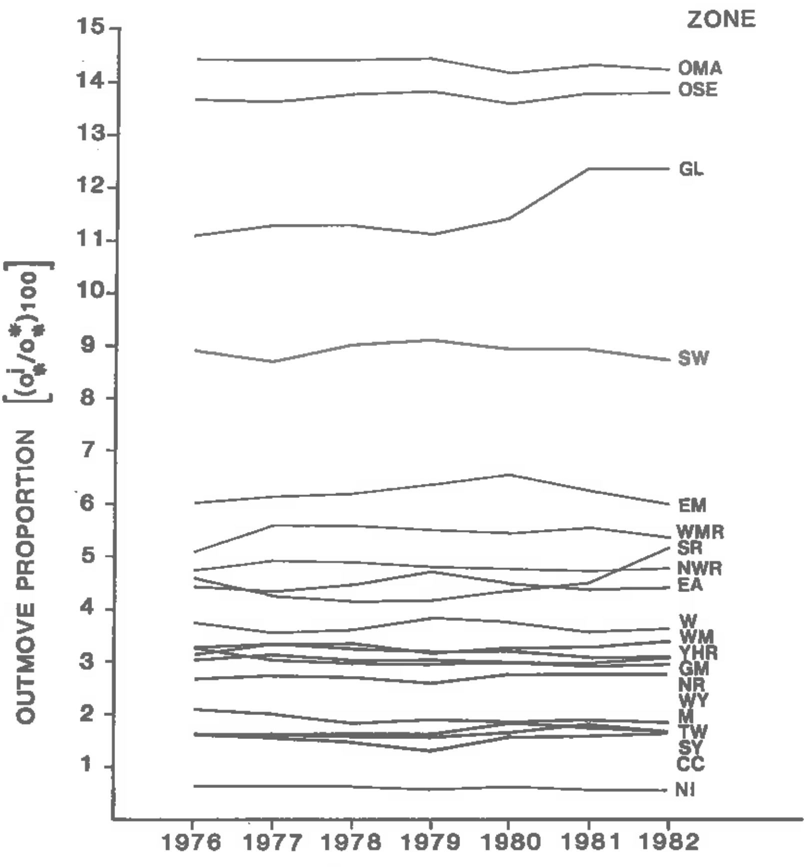


**Figure 12.** Outmove proportions; study zones, 1975-76 to 1981-82

## 4. The development of a Modelling System for Migration Projection

### 4.1 Migration modelling and population projection

There exists in the literature a wide variety of migration models and although a broad distinction can be drawn between spatial interaction models, intervening opportunities models, econometric models and probability models (Stillwell, 1975) on the basis of structural form and calibration methodology, each has its own specific characteristics in terms of the definition and measurement of the migration variable, the zone system used and the effects which the model builds in. Regression techniques are frequently used for explanatory analysis in order to determine the effects of independent variables upon migration.

The development and use of migration models for projection and forecasting is less well-advanced, and most studies have been undertaken in the context of population projection (Gilje and Campbell, 1973; Joseph, 1977; and Martin, Voorhees and Bates, 1981). Given the importance of the migration component in population change, it becomes essential to develop a system which integrates the projection of both population and migration, in such a way that it is possible to explore the consequences of using alternative migration models or of making particular choices about the way in which projections are constructed (Rees, 1983). The accounts-based model for age-disaggregated population projection described in Rees and Wilson (1977) was the advantage that inter-zonal flows rather than net flows can be incorporated explicitly. We must recognize that there is not necessarily a best method of projecting inter-zonal flows within a system. Rather, there are likely to be a number of alternative methods which may be applicable, the choice of which will depend upon factors such as the extent of the availability of historical time series, the characteristics of the flows and the purpose for which projections are constructed. It is therefore in our interest to develop a system which includes a range of models for migration projection so that different types of model can be selected under a variety of data situations and so that projections generated by different methods can be compared and evaluated.

If we assume no information about the projection period except the initial age-disaggregated population stocks, there are three questions which are particularly important since they dictate the type of models selected:

(1) Is inter-zonal migration to be projected directly or through stages involving projection of overall levels or gross flows?

(2) Is age-disaggregated inter-zonal migration to be projected directly or through stages involving age group aggregation and deconsolidation procedures?

(3) Is there a requirement to incorporate non-demographic variables?

The first question provides the focus for the remainder of this paper. Methods of projecting migration levels, zonal outmigration and inmigration totals, and inter-zonal flows are outlined in the following section and age-disaggregated NHSCR movement data is then used to test a set of alternative models. The second question raises the issue of whether migration projections should be initially generated at an aggregate or broad age group level and subsequently deconsolidated into smaller age groups. The decision to adopt this type of approach may become necessary if projections are required for one year age group flows and methods involving model migration schedules can be employed in this situation. Further research is required to compare the results of projections involving aggregate modelling and age group deconsolidation with those reported in this paper. The incorporation of non-demographic data is feasible with several of the models outlined but projections of variables influencing migration are frequently less reliable than projections of migration based on demographic information. Consequently migration projection has tended to be undertaken on the basis of rates analysis or trend extrapolation where time series data is available.

### 4.2 Migration projection methods

There are theoretical arguments which suggest that migration occurring between a set of areal units can be partitioned into three components, each of which is likely to be influenced by a different set of factors. The first component is the general migration propensity, measured by the total number of inter-zonal moves that occur in the system. Secondly, there is the migration generation (or attraction) component which is represented by the gross outflow (or inflow) from (or into) any given zone. The third component is the distribution component which refers to the flow of migrants from zone i to zone j. There exists a variety of methods for projecting each of these components.

#### 4.2.1 Projecting levels of migration

The projection of migration levels, like that of gross flows, depends upon the extent of the data time series. If data for only one historical period is available, projections for age group a can be generated using a rate ($l_a$) defined as

$$l_a = \sum_i \sum_j M_a^{ij} \; (t, t{+}T) \; / \sum_i P_a^i \; (t) \qquad (18)$$

where $\sum_i P_a^i$ refers to the total population in age group a at the beginning of the historical period (t, t+T).

This rate can then be applied to a projection period population. When data is available for two historical periods (t, t+T) and (t+T, t+2T), projections can be generated according to the changes observed between the two periods. A migration propensity multiplier $lm_a$ can be defined on the basis of change in flow totals:

$$lm_a = \sum_i \sum_j M_a^{ij} \ (t, \ t+T) / \sum_i \sum_j M_a^{ij} \ (t+T, \ t+2T) \tag{19}$$

or change in rates:

$$lm_a = \frac{\sum_i \sum_j M_a^{ij} \ (t, \ t+T)}{\sum_i P_a^i \ (t)} \bigg/ \frac{\sum_i \sum_j M_a^{ij} \ (t+T, \ t+2T)}{\sum_i P_a^i \ (t + T)} \tag{20}$$

As the time series is extended, more sophisticated methods of extrapolation can be used to generate trend-based projections. Ideally, projections should be sensitive to the likely effects on migration of fluctuations in the economy or changes in technology for example, but this requires formal measurement of the relationships involved.

4.2.2 Projecting gross migration

Similar methods to those described above can be used to prepare projections of gross zonal outmigration or immigration or both. Historical outmigration rates $(o_a^i)$ defined as:

$$o_a^i = \sum_j M_a^{ij} \ (t, \ t+T) / P_a^i \ (t) \tag{21}$$

can be applied to projection period populations either directly or after adjustment for changes in the general level of mobility using the multiplier defined in equation (19) or (20). Gross immigration projections should theoretically be produced using admission rates, where the at risk population stocks are those persons in age group a in each zone at the end of the period. However, end-of-projection period populations are often unavailable.

An alternative method of generating gross flow projections assumes that the overall level of migration has been projected independently. The empirical evidence presented in section 3.4 indicated that gross proportions remain stable over time, and consequently, the overall total can be disaggregated on the basis of probabilities observed in the historical period. The outmigration probability $(po_a^i)$ is defined as:

$$po_a^i = \sum_j M_a^{ij} \ (t, \ t+T) / \sum_i \sum_j M_a^{ij} \ (t, \ t+T) \tag{22}$$

and if adequate time series is available, projections of gross outmigration or immigration probabilities can be trend-based. Further methods of gross inflow projection might involve adjustment of historical immigration rates using multipliers reflecting the changes in each zone's proportion of total employment, or use of the relationship between immigration rates and outmigration rates which been shown to exist for mobility within certain zone systems (Cordey-Hayes and Gleave, 1974).

### 4.2.3 Projecting inter-zonal migration

The distribution of migrants between origin and destination zones can also be achieved in several different ways, depending upon the amount of information that is provided exogenously and which can be used to constrain the flow projections. The simplest type of distribution model is one in which $\tilde{M}_a^{ij}$, the projected migration flow between zone i and zone j of persons in age group a, is estimated by applying $m_a^{ij}$, the migration rate observed for a previous historical period, to $\tilde{P}_a^i$, the age group population at the commencement of the projection period. The model is:

$$\tilde{M}_a^{ij} = m_a^{ij} \quad \tilde{P}_a^i \tag{23}$$

where the symbol ~ indicates that the variable is associated with a projection period. The population stocks are generated by the account-based model and input to the migration model. This type of model is popular in forecasting (Joseph, 1975) and the results obtained can be used as a standard for comparing projections constructed using other methods.

A second type of model is one in which projected totals of migration in each age group ($L_a$) are distributed on the basis of two probabilities derived from data for an historical period. This type of model has been used for historical analysis of Dutch data by Baydar (1983). A conditional probability projection model has the form:

$$\tilde{M}_a^{ij} = \tilde{L}_a \, po_a^i \quad pm_a^{ij} \tag{24}$$

where $po_a^i$ is the gross outmigration probability defined in equation 22, and

$$pm_a^{ij} = M_a^{ij}\,(t,\ t+T) / \sum_j M_a^{ij}\,(t,\ t+T) \tag{25}$$

representing the probability of migration to zone j, given that the migrant originates from zone i. An alternative formulation can be expressed which distributes the total figure according to the probability of migration from zone i conditional on the probability of immigration to zone j.

If gross out- and immigration flows are projected independently, growth factor methods can be used to distribute these totals on the basis of the migration distribution associated with a historical period. A doubly constrained growth factor model for migrants in age group a, has the form

$$\tilde{M}_a^{ij} = \tilde{A}_a^i \quad \tilde{B}_a^j \quad \tilde{g}_a^{ij} \quad M_a^{ij} \tag{26}$$

where the growth factor is

$$\tilde{g}_a^{ij} = (\tilde{O}_a^i / O_a^i)(\tilde{D}_a^j / D_a^j) \tag{27}$$

and where the balancing factors, $\tilde{A}_a^i$ and $\tilde{B}_a^j$, ensure that the row elements for each zone sum to the respective projected gross outflow total, and the column elements for each zone sum to the projected gross inflow total. The effect of historical dependence is implicit in this model which factors the observed matrix according to the product of the ratio between the projected and the historical row and column sums.

Spatial interaction models can also be used for the purpose of generating flow distributions from gross flow totals, although calibration is required prior to projection in order to estimate the best-fit parameters. In the doubly constrained model, the gross totals represent precise estimates of origin and destination zone 'attractiveness' and the impact of distance on migration is introduced through a negative power or a negative exponential distance function. Origin zone-specific decay parameters are used for projection if they improve model fits for the historical period. The projection model can be written as

$$\tilde{M}_a^{ij} = \tilde{A}_a^i \ \tilde{B}_a^i \ \tilde{O}_a^i \ \tilde{D}_a^j \ d^{ij\,-\beta_a^i} \tag{28}$$

When projections of either gross outmigration or gross inmigration are unavailable, singly constrained models can be constructed in which the attractiveness of either origins or destinations is represented by other types of data. The use of economic indicators to represent the destination attractiveness term is one mechanism for linking migration projections with economic forecasts.

The methods which have been described in this section do not make up a comprehensive set of migration models. They represent a selection of models whose predictive capabilities we wish to compare in the next section.

## 4.3 A comparison of four approaches to movement projection

There are very few studies reporting the accuracy of alternative migration projections. The aim of this section of the paper is to explore the effectiveness of approaches described previously by using them to generate projections which can be compared against 'observed' flows. The NHSCR movement data is used for this purpose and the year commencing mid-1979 has been chosen as the base period for producing forecasts of age-disaggregated inter-zonal moves during 1980-81 and 1981-82. Statistical indices are required to measure the degree of agreement between projected and 'observed' flow matrices. The results are reported in terms of the average deviation between the 'observed' and projected flows for each age group, or:

$$\frac{\sum_{i}\sum_{j}\left|M_a^{ij} - \tilde{M}_a^{ij}\right|}{\sum_{i}\sum_{j} M_a^{ij}}$$

This summary measure, usually expressed as a percentage, is rather crude but has the advantage of being relatively easy to interpret.

The projections are divided into four sets. The first set are those constructed using a simple rates model, and Figure 13 indicates the amount of variation in the average deviation between age group projections for each of the two periods. The average deviation varies from 7.8% (30-34 age group) to nearly 17% (65-69 age group) in the first period and there is a tendency for more accurate projection of movement in the younger age groups where the flows are larger. Projections for 1981-82 are less accurate than those for 1980-81 in the younger age groups but more accurate in certain of the older groups.

The second set of projections are generated by a conditional probability model supplied with rate-based projections of age group movement levels. These projections tend to be only marginally less accurate than those incorporating observed levels of movement (Figure 14) and the pattern of deviation across the age groups in both projection periods resembles the pattern observed from the first set of projections.

The third and fourth sets of projections are two-stage projections in which gross flows are forecast separately and distributed in the second stage. One subset of projections involves rate-based gross flow projections whereas the other subset contains gross flow projections based on forecast movement levels which are disaggregated into zonal out- and inflow totals using historical probabilities. These subsets are compared against a third subset in which observed gross flows are input. Figure 15 shows the average deviations for projections of inter-zonal moves in which a doubly constrained growth factor model has been used for distributing the gross flows. The magnitude of deviation and the pattern of variation between age groups is similar to that of the first two sets of projections with little to choose between rate-based and probability-based gross flows in the first projection period. In the second projection period, the margin of error increases in the younger age groups in particular and projections with probability-based gross flows are superior in most age groups. When observed gross flows are distributed, the average deviation falls to between 5.1% and 4.1% in 1980-81 and between 6.2% and 5.1% in 1981-82. This set of results illustrates the proportion of deviation which is attributable to the distribution model specifically and confirms the need to improve on the methods of gross flow projection which have been used so far.

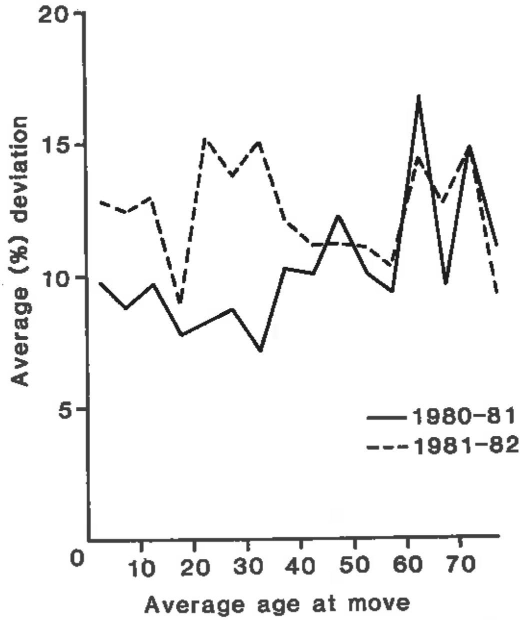


Figure 13. Average (%) deviations of 1979-80 based age-specific projections for 1980-81 and 1981-82 using a simple rates model.

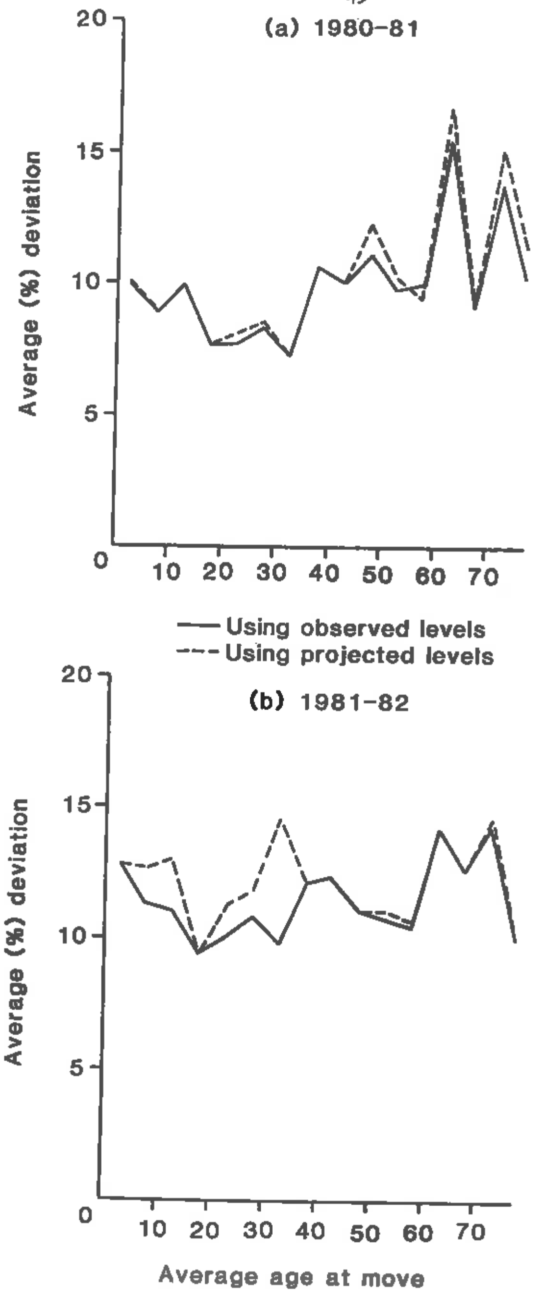


Figure 14. Average (%) deviations of 1979-80 based age-specific projections for (a) 1980-81 and (b) 1981-82, using a conditional probability model

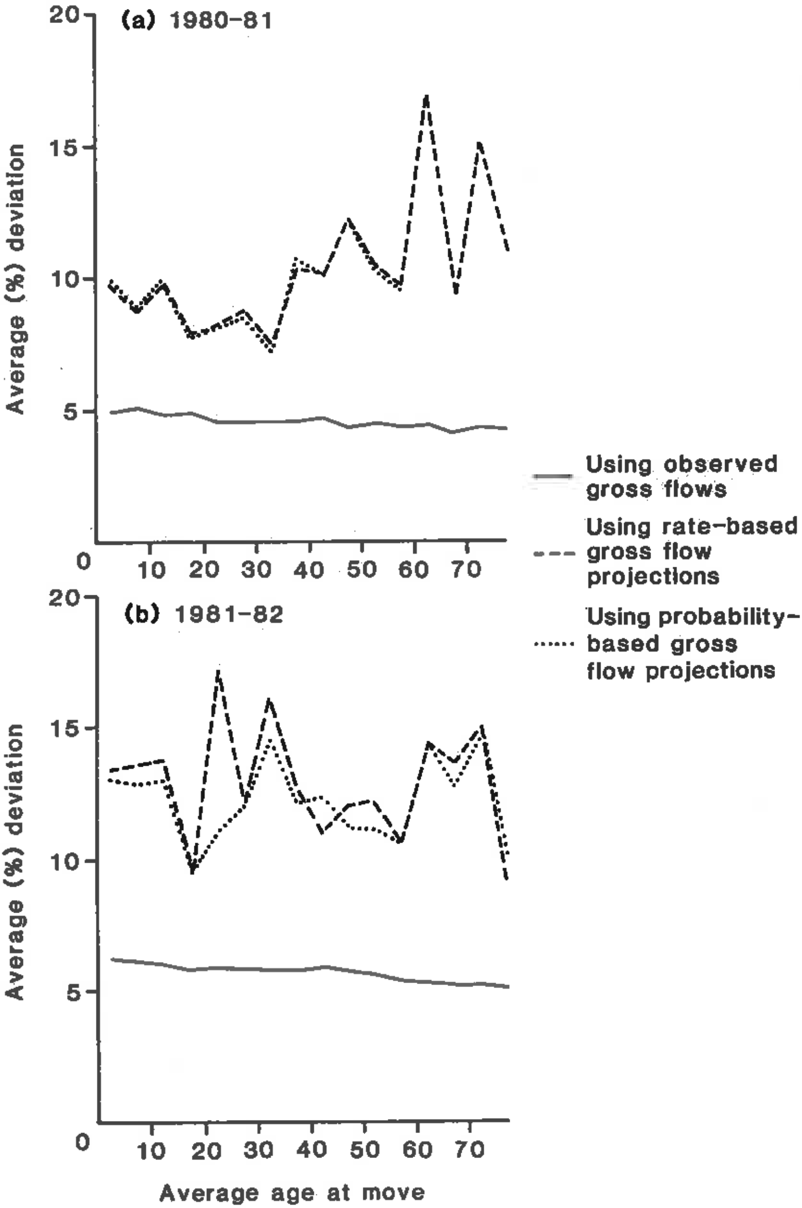


Figure 15. Average (%) deviations of 1979-80 based age-specific projections for (a) 1980-81, and (b) 1981-82, using a doubly constrained growth factor model

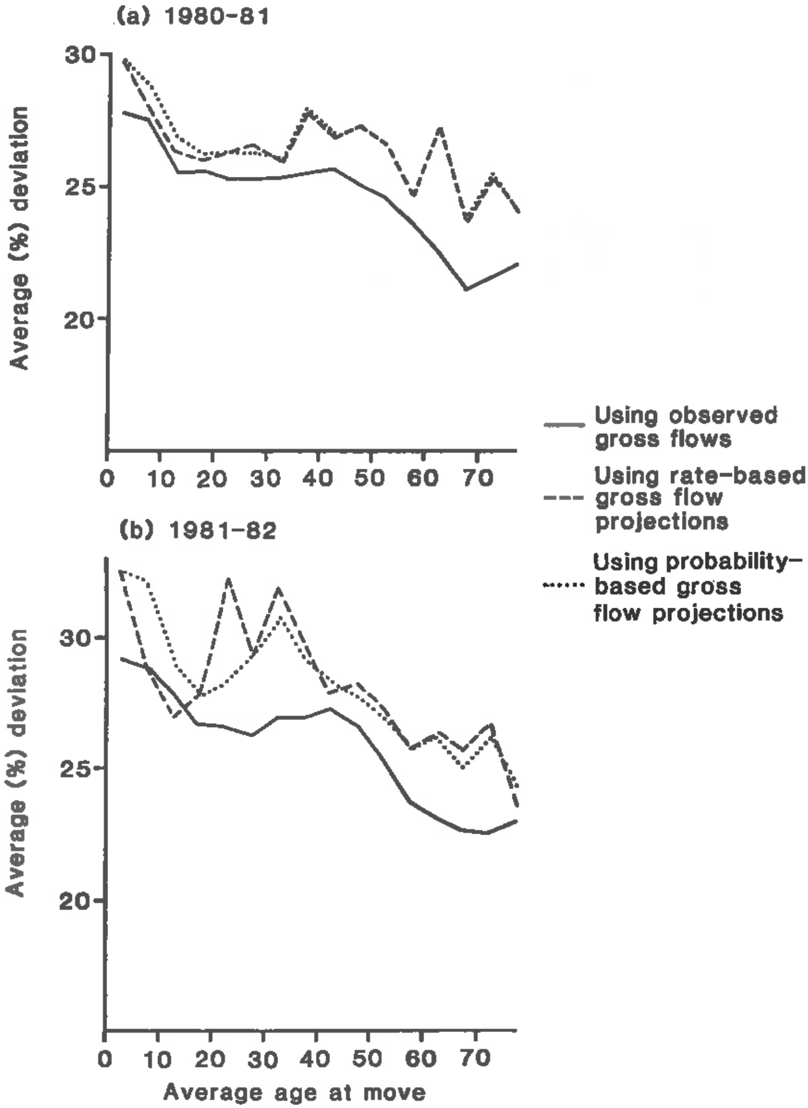


Figure 16. Average (%) deviationsof 1979-80 based age-specific projections for (a) 1980-81, and (b) 1981-82, using a doubly constrained spatial interaction model

A final set of projections was prepared using a doubly constrained spatial interaction model with origin-specific decay parameters. The results (Figure 16) indicate a decline in the goodness of fit compared with other approaches. The average deviation fluctuates between 23 and 30% for both subsets involving projected gross flows for 1980-81, and most of the deviation is accounted for by the distribution model in both projection periods. There is a tendency for the model to generate better projections in the older age groups, where the influence of distance on migration is more pronounced.

4.4 A method for estimating transition flows

Population accounts and population projections can be developed using either transition data or movement data. Ogilvy (1980) has shown that it is possible to compare transitions with moves, but movement data cannot be used directly in the preparation of transition accounts. An initial aim of the main research project was to develop a set of historical transition accounts linking the census years 1966 to 1981. In order to do this, we must estimate transition flows for 1971-76 and 1976-81. A procedure for estimating transition data for 1976-81 which makes use of the available movement data but which does not confuse the two measures of migration begins with the calculation of age-specific out-migration rates for each origin zone for 1966-71 as:

$$o_a^i \ (1966\text{-}71) = O_a^i \ (1966\text{-}71) / \ P_a^i \ (1966) \tag{29}$$

Annual movement matrices for 1976-77 to 1980-81 are aggregated to give a set of mid year to mid year flows and a multiplier measuring change in the proportional share of outmigration from each zone in each age group is calculated as:

$$f_a^i = \frac{O_a^i \ (1966\text{-}71) / \ O_a^* \ (1966\text{-}71)}{O_a^i \ (1976\text{-}81) / \ O_a^* \ (1976\text{-}81)} \tag{30}$$

This multiplier is used to adjust the outmigration rates to reflect sectoral change, and the adjusted rates are applied to 1976 populations to generate gross outmigration totals for 1976-81. These totals can be disaggregated into flows to each destination by applying the probabilities ($p_a^{ij}$) of migration between zones which are derived from the 1976-81 movement matrix. The model can be expressed as:

$$M_a^{ij} \ (1976\text{-}81) = o_a^i \ (1966\text{-}71) \ f_a^i \ \ p_a^{ij} \ (1976\text{-}81) \ P_a^i \ (1976) \tag{31}$$

$$\text{where } p_a^{ij} \ (1976\text{-}81) = M_a^{ij} \ (1976\text{-}81) / O_a^i \ (1976\text{-}81) \tag{32}$$

Transition data available from the 1981 census will clearly be valuable in verifying the relationship between the two types of migration data for 1980-81.

## 5. Conclusions

The long term aim of this research is to construct a system for producing projections of age-disaggregated migration that can be used in population forecasting. In the course of doing so, it is helpful to examine some of the characteristic features of internal migration in the UK. The empirical results presented in this paper verify the potential of adopting the metropolitan and non-metropolitan regions as a set of study zones. The process of decentralization from large urban centres to their respective rural hinterlands is one of the most important characteristics of the pattern of UK internal migration in the last twenty years. In addition, there emerges a distinct hierarchy of areas, ordered on the basis of net inflows from other zones in the system. The aggregate pattern of metropolitan net losses and non-metropolitan net gains is consistent across most age groups, with certain exceptions, and although the general pattern of flows remained the same between 1966-71 and 1976-81, the evidence suggests a decline in each metropolitan area's share of total outmigration and an increase in each area's share of total immigration. A slowing down in the process of decentralization is most apparent for Greater London, and moreover, the annual movement data since 1975-76 indicates a decline in the level of mobility throughout the UK. Outmove and inter-zonal move proportions confirm that while the level of migration fluctuates, the spatial pattern remains fairly stable. The main characteristic of change in the age structure of movement since 1975-76 is the downward trend in proportion of infants and children aged 5-9 moving with their parents in the 25-29 age bracket.

The paper has drawn attention to the limitations of both census-based transition data and register-based moves data and to the difficulties faced in preparing and comparing different types of data for a common zone system. The investigation of spatial and age group differentials in the propensity to migrate over distance has shown that there is no necessary relationship between the location of one zone relative to others and the influence of distance upon outmigrants from that zone or migrants to that zone. There is a tendency for the friction of distance effect to be greater on outmigrants from metropolitan zones than on those from non-metropolitan zones, and on migrants in the latter half of the age range. The magnitude and spatial pattern of variation in zone-specific distance decay parameters calibrated for aggregate flows are similar between 1966-71 and 1976-81, but age differentials are not strictly comparable between the two periods.

The empirical analyses reported in section 3 of the paper provide several clues about effective methods of constructing projections. In particular, decomposition enables separate projection of the more stable and less stable components of migration. Historical dependence models based on conditional probabilities or growth factors are therefore likely to be suitable for distributing projected levels or gross flows. In Section 4, age-disaggregated projections constructed using these models were compared alongside sets of projections generated using a simple rates approach and a doubly constrained spatial interaction model. The mean age group deviation between 'observed' and projected flows for 1980-81 and 1981-82 is significantly larger for the spatial interaction model whereas the other three methods produce projections which are similar in the magnitude and age group pattern of deviation. One of the problems with these tests of projection is that the observed age-disaggregated data itself has been estimated and this renders the results less meaningful. Nevertheless, it can still be argued that the proportion of error attributable to the distribution process is still significantly lower in the case of the growth factor model, and an approach which distributes gross flows on the basis of the pattern of historical migration has the potential to produce more accurate projections.

Further work is clearly required to develop more advanced methods of gross flow projection which utilize the available time series data, to test alternative projection methods using more specific statistical indices, to explore the consequences of modelling age-aggregated flows, which can subsequently be deconsolidated, and to examine methods of incorporating non-demographic information.

References

Baydar, N. (1983) Analysis of the temporal stability of migration patterns in the context of multiregional forecasting. Working Paper No 38, Netherlands Interuniversity Demographic Institute, Voorburg

Census Division, OPCS (1981) The first results of the 1981 census of England and Wales. Population Trends, 25, 21-29

Cordey-Hayes, M. and Gleave, D. (1974) Migration movements and the differential growth of city regions in England and Wales. Papers of the Regional Science Association, 33, 99-123

Craig, J. (1981) Migration patterns of Surrey, Devon and South Yorkshire. Population Trends, 23, 16-21

Department of Environment (1971) Long term population distribution in Great Britain - a study, HMSO, London

Department of Environment, Yorkshire and Humberside Regional Office (1979) A study of migration in Yorkshire and Humberside, 1966-71, Unpublished Report

Edwards, S. L. and Pender, M. (1976) Migration within Great Britain, Statistical News, 34, 17-19

Elias, P. and Molho, I. (1982) Regional labour supply: an economic/demographic model, in OPCS Occasional Paper 28, OPCS, London

GRO, Northern Ireland (1975) Migration Tables, HMSO, Belfast

Gilje, B. K. and Campbell, R. A. (1973) A new model for projecting the population of the Greater London boroughs, Research Memorandum No 408, Department of Planning and Transportation, Greater London Council

Gordon, I. (1982) The analysis of motivation-specific migration streams, Environment and Planning A, 14, 5-20

Hyman, G. and Gleave, D. (1978) A reasonable theory of migration, Institute of British Geographers Transactions, New Series 3, 179-201

Joseph, G. (1975) A Markov analysis of age/sex differences in inter-regional migration in Great Britain, Regional Studies, 9, 69-78

Joseph, G. (1977) Inter-regional population distribution and growth in Britain - a projection exercise, Scottish Journal of Political Economy, XXI (2), 159-169

Kennett, S. (1980) Migration within and between the metropolitan economic labour areas of Britain, Chapter 7 in Hobcraft, J. N. and Rees, P. H. (eds) Regional Demographic Development, Croom Helm, London

Martin and Voorhees Associates and John Bates Services (1981) Developing the migration component of the official sub-national population projections. Final Report. Prepared for DPRP3 Division, Department of Environment, London

Masser, I. (1970) A test of some models for predicting inter-metropolitan movement of population in England and Wales, University Working Paper No 9, Centre for Environmental Studies, London

OPCS (1978) Census 1971. Great Britain. Migration Tables (10% sample) (Areas as constituted on April 1 1974 for England and Wales and May 16 1975 for Scotland), HMSO, London

Ogilvy, A. A. (1979) Migration - the influence of economic change, Futures, 11(5), 383-394

Ogilvy, A. A. (1980) Interregional migration since 1971: an appraisal of data from the National Health Service Central Register and Labour Force Surveys, OPCS Occasional Paper 16, OPCS, St Catherines House, Kingsway, London

Ogilvy, A. A. (1982) Population movements between the regions of Great Britain 1971-79, Regional Studies, 16 (1), 65-73

Osborne, R. H. (1956) Internal migration in England and Wales 1951, Advancement of Science, 12, 425-434

Ravenstein, E. G. (1876) Birth places and migration, Geographical Magazine, 3, 173-177, 201-206 and 229-233

Ravenstein, E. G. (1885) The laws of migration, Journal of the Royal Statistical Society, 48, 167-235; 52, 241-305

Rees, P. H. (1977) The measurement of migration from census and other sources, Environment and Planning A, 9, 247-272

Rees, P. H. (1979) Migration and settlement: 1. United Kingdom, Research Report RR-79-3, International Institute of Applied Systems Analysis, Laxenburg, Austria

Rees, P. H. (1983) Choices in the construction of regional population projections, Paper presented at the Anglo-Dutch Migration Symposium, (14-16 September), Soesterberg, Netherlands

Rees, P. H. and Stillwell, J. C. H. (1982) An integrated model of migration flows and population change for a system of UK metropolitan and non-metropolitan regions: a framework, Working Paper 332, School of Geography, University of Leeds

Rees, P. H. and Wilson, A. G. (1977) Spatial Population Analysis, Edward Arnold, London

Rogers, A. and Castro, L. J. (1981) Model Migration Schedules, RR-81-30, Institute of Applied Systems Analysis, Laxenburg, Austria

Rogers, A., Raquillet, R. and Castro, L. J. (1978) Model migration schedules and their applications. Environment and Planning A, 10, 475-502

Stillwell, J. C. H. (1975) Models of interregional migration: a review, Working Paper 100, Department of Geography, University of Leeds

Stillwell,J. C. H. (1978) Inter-zonal migration: some historical tests of spatial interaction models, Environment and Planning A, 10, 1187-1200

Stillwell, J. C. H. (1979) Migration in England and Wales: a study of inter-area patterns, accounts, models and projections, Unpublished PhD Thesis, School of Geography, University of Leeds

Somermeijer, W. H. (1971) Multi-polar human flow models, Regional Science Association Papers, XXVI, 131-144

Weeden, R. (1973) Inter-regional migration models and their application to Great Britain, National Institute of Economic and Social Research, Regional Papers II, Cambridge University Press

Welsh Office (1979) Migration into, out of and within Wales in the 1966-71 period, Welsh Office Occasional Paper No 4, HMSO, Cardiff

Wilson, A. G. (1974) Urban and Regional Models in Geography and Planning, Wiley, London