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HOW THE DUTCH AND THE ENGLISH ADOPTED MULTIREGIONAL MODELS FOR SUBNATIONAL POPULATION PROJECTION

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ABSTRACT

The Netherlands and the United Kingdom have both introduced multiregional models to carry out part of the task of projecting the population of subnational areas. This paper describes and compares these efforts. They are also evaluated in two ways: against the requirements of potential users of forecasts and against the principles that should be applied in sound multiregional population models.

1. INTRODUCTION

In both the Netherlands and the United Kingdom national government departments responsible for the production of population projections for both the nation and subnational units have recently sought to improve those projections through the development and implementation of new multiregional models. Researchers and consultants outside of central government were asked to prepare these models (Martin & Voorhees Associates and Bates 1981; Willekens and Drewe 1981, 1984). In this paper these efforts are described and compared in order to assess what has been achieved to date and what improvements could be effected. A particular emphasis is laid on assessment of the outputs available from such models.

In the next section of the paper the needs of users of subnational population projections are assessed. In section three the conceptual bases of multiregional models are briefly reviewed. Section four outlines the nature of the data bases available for use in population projections in the two countries. The fifth section outlines and compares the new population models. The final part of the paper assesses the models and elicits lessons.

2. FORECASTING REQUIREMENTS

Here we review the demands of users of population projections rather than the wishes of population modellers. The latter need to assess the requirements of the "market" for their product carefully, and to invest rather more attention than hitherto in the presentation of model outputs. Because of the large number of variables used in multiregional population models, this issue must be the concern of the model designer/systems analyst, and not just a task relegated to a later stage in the development of a projection system.

2.1 Population numbers, age disaggregation and time intervals

Users of population projections, be they planners or academics, most usually require knowledge of population numbers at short intervals for varying periods into the future.

The populations are broken down into detailed age groups, not for their own sake, but in order to yield good estimates of target client or service or market populations. Examples are the school populations in various grades, the numbers of potential students qualified to enter higher education, the labour force, or the retired population. The age classification of the population needed to estimate these target populations must be as fine as possible, preferably by single years of age.

Full details of all single year age populations are rarely required but flexible aggregations of these ages are needed. For example, to assess the viability of alternative plans for school reorganization in Leeds, the City Education Committee required projections for the 5-8, 9-13, 14-18 age groups in one scheme, and the 5-10, 11-16, 17-18 age groups in another.

Very often, population numbers themselves are insufficient to define the target population. Further disaggregation may be needed. In the school planning case, an estimate is required of the proportions in any age group entering independent and state supported schools, and within the state sector the proportions or numbers likely to enter Roman Catholic, Anglican or secular schools.

2.2 Detailed inputs and outputs

Most population projection models can be designed to yield not only fine detail on the population stocks at regular intervals but also fine detail on the demographic components that link successive population stocks. Users do not normally require, for example, detailed information on mortality or migration rates used in the projections by single years of age, but they probably wish to know what those rates mean in terms of summary measures such as the crude death rate, life expectancy, the crude migration rate or gross migra-production rate. A detailed account of interregional migration by single years of age is seldom used but a summary of interregion flows by broad age groups would be of interest. But if the number of regions was large, even an interregion matrix would be too detailed, and a summary of the main or total inflows and outflows for each region would be preferable.

To generalize this point, we can say that multiregional population projection models operate with variables at a level of disaggregation much finer than that required by most users and that any implementation of such models should aim to provide relevant summaries of the information generated.

2.3 An example of projection outputs

To exemplify these points, we examine the practice adopted by the United Nations (UN) in their latest, very useful set of population estimates and projections as assessed in 1982 (UN, 1985). The results for the Netherlands and the United Kingdom are reproduced in Appendix 1.

Tables A.2 and A.4 show the estimates and projections of the populations of the two countries at 5 year intervals from 1950 to 2025 for both sexes and for 5 year age groups to 80+ years in a one page format (compressing two pages of computer printout).

Tables A.1 and A.3 summarize the population stock information by broad age groups and provide a set of indicators of the age and sex structure of the population in the first of three sub-tables. The second sub-table provides information on component rates in the 5 year time intervals and summarizes the fertility and mortality levels using nine indicators. The final sub-table gives a selection of the indicators for high fertility and low fertility variants.

The same set of statistics is provided by the UN for all constituent countries and for continental, sub-continental and more/less developed areas, so that comparisons across and between all scales are a simple matter. All the statistics are available to users on magnetic tape for further analysis.

A key feature of the UN projections is the emphasis on presenting statistics over time: time points or intervals are used as the column dimension in all tables. Time series analysis of the results is intended and made easy by such a presentation (e.g. Keyfitz and Vaupel, 1986). The UN projections provide guidelines against which the presentation of subnational projection results can be assessed.

What is less satisfactory about the UN projections, however, is the lack of detail provided about the models and programs used to generate the results. UN(1985, p.3) suggests that 5 year time and age intervals were used throughout to generate tables of the A.2 and A.4 type, but no details are provided on the methods used to produce the annual population figures and other age group numbers contained in the first sub-table of the A.1 and A.3 type.

2.4 A specific or a general model?

Population projection models and their associated software may be specific to the particular system being studied or they may be used more generally with a variety of systems of interest. Academic researchers incline to the latter kind of model because they wish to study many different systems; government researchers prefer the former, both because the model and associated software are easier to design and because their attention is focussed on the current set of subnational units.

This issue is far more serious if a multiregional modelling strategy is adopted. A single region cohort survival model with net migration rates or flows does not require alteration when used with more regions. The same model is simply used more times. However, in multiregional models an expansion from N regions to 2N may require redesign of the software (because interaction variable dimensions increase in proportion to N squared) or redesign of the model (because with very many regions in relation to the size of the population many of the cells in the migration matrix may contain small and unreliable numbers). The model used will vary with the size of the system being modelled.

Although system specific models are easier to design and program, even in governmental use there will be problems occasioned by the freuent re-specification of subnational areas prompted by politicians either because the settlement system has changed or because electoral advantage may be thereby gained. It may be worthwhile, therefore, investing in a more general model for long term use designed to withstand severe "spatial shock".

2.5 Issues concerned with the spatial units adopted

The strategies for modelling the populations of a large number of regions have been reviewed in Rogers (1976) and Rees (1979a, 1981b) and may be summarized as follows.

(1) Fully multiregional
All regions in the system are modelled simultaneously in a multiregional model in full age and sex detail. Problems of small numbers or unreliable data are ignored.

(2) Partitioned
The system of regions may be partitioned into sub-systems, interregional migrations within which are modelled explicitly while migration between regions in different subsystems is modelled at the subsystem level.

(3) Aggregated
Some of the variables in the system are aggregated or pooled across the spatial or the age dimension of the model. For example, in the subnational projections for England (OPCS, 1984) migration between 108 subnational units is modelled for three aggregate age groups (see section five for more details). Another popular choice is to divide the migration process into a process of choosing to move and a process of selecting a destination (Frey, 1984).

(4) Biregional
In this strategy the system is collapsed into N sets of 2 regions consisting of the area of interest and the rest of the nation (although flows to and from the rest of the world should also be incorporated in the model).

All the strategies listed above can be termed "multiregional" because they retain at least some of the interactions and interdependency between regions. Solutions (1) and (4) lead to general and portable models. Solutions (2) and (3) result in models specific to the system being studied. Each solution will yield a different set of projections, and the subnational projections will not necessarily add to the figures obtained in projecting the national population. A decision has then to be made about whether to adjust the subnational populations or to accept their sum as the national projections.

2.6 Summary of the user's requirements for a subnational population projection model

To summarize, users of population projections for subnational units require:

(1) future populations classified by single years of age and sex;
(2) summary measures of the inputs to the projections for each interval;
(3) summary measures of the components of change in each future period;
(4) time oriented presentation of the projection results;
(5) standard presentation of the projection results at all scales;
(6) a model (or its software) general enough to cope with a redefinition of the spatial units of projection; and
(7) an effective strategy for projecting the populaton of a large number of units, either across the country or within a particular region.

Having discussed the needs of users of forecasts and some of the issues that producers of national forecasts face, we review in the next section the main features of multiregional population modelling.

3. MULTIREGIONAL POPULATION MODELLING: THE BARE NECESSITIES

3.1 The case for multiregional population modelling

A strong case has been made for two decades now that the only proper way to project regional populations is to model explicitly the migration flows between them along with the mortality, fertility and external migration components involved (see Rogers 1985a, 1985b, Willekens 1985b and Rees 1986a for recent surveys). Use of net migration rates or flows can lead in the long run to absurd results. By explicitly modelling interregional migration flows using interregional transition rates, the influence of one region's population dynamics on that of another is captured. The same case can be made for explicitly modelling international migration in a similar way but data difficulties usually mean that a net flow or rate term is used. However, external migration must be included in a regional population projection in order to close the population account (Rees 1986b).

3.2 Migration concepts and projection models

For nearly a decade now a clear link has been recognized between the form in which migration activity is recorded and the form which the multiregional population projection model should take (Rees 1977; Ledent 1978, 1979; Ledent and Rees, 1980, 1986; Rees 1985). There are three principal sources of migration data: censuses, population registers and surveys. Survey data on migration are not as yet used much for projection purposes and they are not considered further here.

The national census frequently contains a retrospective question on the place of residence at some date in the past. The date can be fixed, for example, when the place of residence n years ago is recorded, or variable, for example, when the place of birth or place of residence at a given age is recorded. Alternatively, the census may contain a question on the previous residence, without any information on the time of migration.

Population registers typically contain information on each change of usual address. Cross-classifications of regions of residence at two points of time are referred to as transition data and migrations data based on changes of residence are denoted as movement data. Transition data are used to compute transition probabilities directly which are entered in the multiregional cohort survival model as rates of migration and survival or survivorship rates. Movement data are used to compute occurrence-exposure rates from which probabilities suitable for entry into multiregional cohort survival models can be estimated.

Figure 1 sets out the broad steps involved in using the two different migration data sets in a multiregional population projection model. Two further points emerge from the diagram. The first is that mortality, fertility and external migration data are similar in the transition and movement approaches. The second is that there are two alternatives in the transition approach. If data are available giving the number of persons surviving and staying in the same region, survivorship rates can be estimated without recourse to mortality data. If they are not available or reliable, the number of surviving stayers must be estimated as a residual thus:

surviving stayers = initial population less internal out-migrants
less emigrants less non-survivors (1)

These computations are best organized in a population accounting framework.

Even if surviving stayer information is available it may still be preferable to incorporate mortality information into the projection process so that the risk of mortality can be separated from that of migration:

$$\text{probability of migrating and surviving} = \text{probability of migration given survival} \times \text{probability of survival} \qquad (2)$$

and the effect of future trends in mortality monitored.

3.3 The role of population accounts

Population accounts are tables which display in a consistent fashion all the inputs from and outputs to a regional population. It is not appropriate here to give a full description (see Rees and Wilson 1977 and Rees 1981a for details of transition accounts and Rees 1984 for details of movement accounts), nor is it necessary to construct accounts before computing the rates that enter multiregional population models. But population accounts do provide yardsticks of the consistency with which population models have been put together, and transition and movement accounts are therefor described here using a British and a Dutch example.

3.4 Transition accounts

Table 1 sets out a set of transition accounts for a three region division of Great Britain for one age group transition in a 5 year period, 1966-71 (from Rees 1979b). The number of surviving internal migrants are entered in the table directly: 7578 between East Anglia and the South East, 8141 from East Anglia to the Rest of Britain, 14408 from the South East to East Anglia and so on to the 84510 from the Rest of Britain to the South East. The fourth column contains an estimate of the numbers of surviving emigrants (5296, 101985, 107473) and the fourth row holds the numbers of surviving immigrants (7790, 88045, 70123). The other data entered in the account are the initial regional populations (101007, 1184032, 2284298) and regional deaths (392, 3998, 8353). An accounts based model is then used (Rees 1981) to estimate the non-survivor elements in the table (the block on the right hand side) and the surviving stayers (79620, 984059, 2074448). The survivor columns of the account can then be totalled to yield the end of period populations. There will be such an account for each age group to age group transition, from the first which involves persons born within the time interval to the last which involves survival of the most aged population 5 years into the future.

The bracketed figures in Table 1 associated with selected cells of the account are transition probabilities or immigration or mortality rates that can be used in a regional projection model. Thus, the number of surviving migrants from the South East to East Anglia would be projected by multiplying the appropriate probability by the population of 20-24 year olds in the South East in 1971 = .01217 x 1,362,256 = 16,579 migrants in 1971-76.

3.5 Movement accounts

Table 2 shows a movement account for a 2 region system in the Netherlands in 1976 for women aged 20 on January 1st 1976 and 21 on January 1st 1977. The account is simpler than that of Table 1 in that total regional deaths no longer appear in the last internal column. The entries in the table are counts of moves between the West Netherlands and the Rest of the Netherlands (1375 and 1739), of emigrations from the two regions (402 and 437), of immigrations to them (759 and 546) or of deaths within them (17 and 23). The diagonal term is computed as a residual (e.g 49121 = 50915 - 17 - 402 - 1375) and is not an event count. The bracketed figures in the table are occurrence-exposure rates in which the occurrences (moves) are divided by the populations exposed to the risk of the event weighted by their exposure (approximated by the average population): thus the rate of movement from the Rest of the Netherlands to the West Netherlands is .02821 = 1739/ 0.5 x (61794 + 61516). To project the population forward using these rates an accounts based model can be used (Rees 1984, 1986a, 1986b) which involves a small number of model iterations or a matrix method can be employed to convert the rates shown in the table into transition probabilities (see Willekens and Drewe 1984). Again there are accounts for each age transition from the first, born in the year to age 1, through 20 to 21 shown in Table 2, to the last, 90+ to 91+. Births are generated in the model using fertility rates and populations at risk in the fertile age range before being subjected to migration and mortality risks. Similarly, the flow of immigration is also subjected to migration and mortality processes. Both types of new arrivals (infants and immigrants) are, however, only exposed for half the time interval, on average, to these forces.

3.6 Age matters

In constructing any population model care must be exercised in adopting the correct age-time plan (ATP) in which the data are observed or estimated. Four age-time plans may be distinguished (Willekens, 1985a): the age-cohort plan, in which events are classified by the cohort to which a person belongs and the age at the time of the event; the age-period (or just period) plan, in which the age and the calendar period at the time of the event are recorded; the period-cohort plan, in which the cohort is recorded to which a person belongs and the calendar period in which the event occurs; and the age-period-cohort plan in which the age and the calendar period at the event together with the cohort are recorded. The period-cohort plan (see Rees and Woods, Figure 12.2) is the appropriate one for projection purposes, and the implementation of any regional projection model is considerably simplified if all age classified data are assembled using this ATP or are converted to it through estimation prior to model specification.

A second age matter is the existence of regularities in the profiles of migration rates by age, thoroughly researched by Rogers and Castro (1986) and by many other authors. Figure 2 shows two examples from the Netherlands and the United Kingdom. These schedules can be summarized as being composed of three or more of the five components shown in the inset to Figure 2. For the Greater London profile in Figure 2 we would use a model with a retirement peak. For the West Netherlands only three components would be necessary. The large number of age specific migration rates (16 for Greater London, 92 for West Netherlands) can be reduced to 9, 11 or 13 model parameters. This proves to be of considerable utility in implementing single year of age multiregional population models.

3.7 Summary of the modelling requirements for a subnational population projection model

Work in the field of spatial population dynamics over the past decade suggests that the following guidelines be followed in designing a subnational projection model.

(1) It should incorporate multiregional features.
(2) Clear cognizance must be taken of the conceptual type of migration data available in designing the projection model. It has proved too easy in the past to muddle model design in this respect.
(3) Although it is not essential to construct population accounts prior to projection, all the components included in population accounts must be consciously incorporated in the projection, either implicitly or explicitly.
(4) It is preferable to prepare all input data for the base period and all rate or parameter changes in the projection periods using the period-cohort age-time observation plan. It has also proved very easy in the past to confuse this problem, which is one of estimation, with that of projection model design.
(5) One useful method for handling the problem of too many variables that occurs in multiregional modelling is to use model parameters rather than rate schedules to represent age-disaggregated migration components (Rogers, 1986).

4. THE DATA BASES

4.1 The data base for the Netherlands

The Netherlands has a rich resource of socioeconomic information about its population. This is extensively reviewed in ter Heide and Willekens (1984), particularly in Part 2: Data in Chapters by van der Erf, by Scheurwater and by Gordijn, Heida and ter Heide. Migration data are also reviewed by Keilman (1986).

In principle, any information required for a regional projection model can be assembled from the migration data of the population register. These data, kept by the municipalities, are assembled by the Central Bureau of Statistics and are accessible through an interactive demographic information system called RUDAP ("Ruimtelijk Demogafische Aspecten van Planprocessen") (Scheurwater 1984). Any set of regions can be assembled as long as they are amalgamations of current municipalities (774 from January 1982 van der Erf, 1984, p.52). The data are available for single calendar years up to the year prior to the present.

Migration data are available from the population register of the Netherlands and are counts of moves from one spatial unit to another, rather than transition counts.

One difficulty is that although the Central Bureau of Statistics prepares migrations and births data files using the period-cohort ATP, this isn't the method adopted for regional mortality data. At the regional level, deaths are classified by age at death and year of death (period ATP). The problem is a coding problem, since the year of birth and date of death are recorded on the death certificate. At the national level, mortality data are available by year of birth, year of death and age at death.

From this account of the data base available in the Netherlands for population projection at subnational scales, it is clear that any regional projection model must be based on the movement concept.

4.2 The data base for the United Kingdom

Demographic information available for subnational areas in the United Kingdom has steadily improved over the past two decades. Births and deaths data are now produced by the Office of Population Censuses and Surveys (OPCS) for very small areas (wards within local authority areas OPCS 1985, p.8), and the deaths data are disaggregated by age (0, 1-4, 5-14, 15-24 and 10 year age groups to 85+). Population data are available from the 1981 Census at the enumeration district (England, Wales, Northern Ireland) or postcode (Scotland) scale (circa 130,000 units). Estimates are made by OPCS of the population at each mid-year following the census at local authority and health district scale. Unofficial estimates have been prepared by the CACI market research firm (OPCS 1985, p.8) at ward level.

Internal migration data are produced in the United Kingdom from two sources: the decennial Census and the National Health Service Central Register (NHSCR) of patient transfers. In the 1981 Census a question about place of residence one year prior to the census data (April 5) was asked and this generated tables of one year transition data for 1980-81 on both a local authority and ward scale. To fill the gap between censuses OPCS have established, in cooperation with the National Health Service, a system for recording changes of Family Practitioner Committee (FPC) areas by patients who re-register with a new FPC as a result of a migration. The FPC areas coincide, for the most part, with local authority areas as currently constituted (except for London boroughs, for which estimates are not available - OPCS, 1985, p.ix). No data are available for intra-area migration, which leads to difficulties when projections are required for finer areas than local authority districts. Prior to 1984 the NHSCR based statistics were published in an aggregate form (in- and out- migrations by age and sex, interarea migrations in total) and estimation methods were used to fill out the full region, age and sex disaggregated array (see Stillwell, 1986). From 1984 the individual migration records have been made available for users to create their own migration counts.

External migration data are generated from the International Passenger Survey (OPCS, 1986) but much careful estimation must be carried out (Rees and Woods 1986) to produce figures for subnational areas. Rather more reliable estimates of immigration for subnational areas are available in the Census but only for the year prior to the census date.

From this account of the data base available in the United Kingdom for population projection at subnational level, it is not clear whether a movement concept or a transition concept population projection model should be designed. In the former case, recourse to census transition data may be necessary to improve initial estimates of migration flows; in the latter case, recourse to NHSCR move data is necessary to update migration patterns for changes since the year prior to the last census.

We now examine what has been accomplished with these data bases.

5. THE PROJECTION MODELS

5.1 MUDEA: a multiregional model for the Netherlands

Between 1982 andd 1984 a multiregional model for subnational population projection was developed at the Netherlands Interuniversity Demographic Institute (NIDI), under the direction of Frans Willekens of NIDI and Paul Drewe of Delft University of Technology under contract to the Physical Planning Agency (RPD) of the Netherlands. The project was overseen by and responded to an inter-ministry Committee for Regional Population Prognoses (CORBEP). The model structure is fully described in Willekens and Drewe (1984) and its intended application is briefly outlined in ter Heide (1984, p.346). Full details of the computer program and applications are available from NIDI.

5.1.1 The model

This model was developed

(1) for two sexes;
(2) for a variable number of regions (up to 40; the number is limited by computer memory);
(3) for flexible age groups (e.g. 1 year or 5 year) and a variable highest age (e.g. 80+ or 90+);
(4) for a projection interval equal to the age interval (generally 1 or 5 years); and
(5) for regional projections that are consistent with exogeneously given national projections (optional).

The modelling strategy adopted was the fully multiregional model (section 2.5) in which the complete array of migration variables (migration disaggregated by 2 sexes, N regions of origin, N regions of destination and NA ages) was used.

The original intention (Willekens and Drewe 1981) was to base the projection model on earlier models developed at the International Institute for Applied Systems Analysis (IIASA) (Willekens and Rogers 1978, Willekens 1979, Ramchandran 1980). In the event, the MUDEA model incorporated substantial changes from the IIASA models.

(1) The model deals with two sexes using a female dominant fertility sub-model. That is, male births are a product of the proportion of births that are male multiplied by a set of fertility rates multiplied by a set of female populations at risk (Willekens and Drewe 1984, pp.329-330).

(2) The age-time plan for the input data was changed from ATP I (the period plan) to ATP II (period-cohort plan) because the focus of interest was projection rather than life table analysis. The original intention to

report on multiregional life expectancies was dropped, although Ledent and Rees (1980, 1986) have shown that such expectancies, at birth, can be generated directly from the projection model's survivorship rates and Rees (1986) has suggested that the whole life table could be estimated from ATP 11 data.

(3) The MUDEA model is clearly and unambiguously based on migration data of the movement type (as generated by the Dutch registration system), whereas the original IIASA models were ambiguous in their input requirements (because the issues involved were only resolved in the course of the associated project).

(4) The MUDEA model is clearly linked to an underlying set of population accounts of the movement variety, although the flow accounting equations are used rather the the full accounts based model.

(5) One consequence of this is that the MUDEA model fully and carefully incorporates international migration into its structure. Emigration flows are treated in the model in the same way as internal out-migration flows, namely as the product of migration rates transformed into period-cohort transition probabilities and the base population. Immigration flows are treated as exogeneous inputs (which are subjected to survival, fertility and migration rates appropriate to their sojourn after immigration).

Thus, the MUDEA model meets the first four modelling requirements set out at the end of section three of the paper. There was a clear intention in the original specification of the project (Willekens and Drewe 1981) that the fifth requirement, that the user be able to "control" the projection by inputting a limited set of key parameters rather than a large body of age specific rates, be met, but this has yet to be accomplished. There is also the ambition (Willekens and Drewe 1981, ter Heide 1984) that the MUDEA model be linked with explanatory models of migration being developed under other RPD research contracts in a second phase. The goal has been partly achieved (Willekens 1986; Drewe 1986; Willekens and Drewe 1986). An analytical framework has been developed which can be used to integrate stability analysis (temporal stability of migration patterns) and explanatory analysis. Four components of migration are distinugished: a level component, a generation component, an attraction component and a spatial interaction component. The components can be studied and projected separately or simultaneously. The contribution of each component to the future migration pattern is determined by its contribution in the past (stability, inertia) and exogeneous factors, such as policy measures, causing the value of a specific component to change.

How general is MUDEA (recalling the discussion of sections 2.4 and 2.5)? It is general in the sense that it can be used with any number of regions (up to 40) and any number of ages, and can be employed in other countries where the same input information is available or can be estimated. In principle, the number of regions could be expanded given sufficient computer memory for the resulting arrays, but the flow and rate estimates would rapidly become unreliable because of the small number problem. The MUDEA model could not be directly used at the local level in the Netherlands (as ter Heide, 1984 recognizes). Another modelling strategy (partitioning, aggregation, parameterization or biregional modelling) would be required.

5.1.2 Inputs

Inputs required for the MUDEA model are:

(1) the start of base year and end of base year populations by sex and age (e.g. 0,1,2, ..., 89,90+) for each region;
(2) births in a year by age (of mother) by region;
(3) births in a year by sex of child;
(4) deaths in a year by age by region and sex;
(5) internal migrations by age by origin, sex and destination;
(6) emigrations by age by region and sex; and
(7) immigrations by age by region and sex.

All age classifications for flows are of the period-cohort type. The migration data are all published by the Central Bureau of Statistics on this basis, but data on childbearing and mortality are published according to age at time of the event (period data). They were converted to period cohort form before being entered in the MUDEA model.

5.1.3 Outputs

Table 3 summarizes the considerable printed output that the MUDEA model produces for each period of analysis. Virtually all the model variables are printed out in full age detail (in most tables the row classification is by age). MUDEA tables 1 and 2 report the start of year populations, tables 3 through 6 report the components of growth (or accounting equation terms) in age detail, tables 8 and 9 report the rates that enter the matrix model, tables 10 to 15 report on internal migration numbers and tables 17 to 18 yield end of period populations. MUDEA tables 7 and 16 provide some summary information.

The outputs of the model are clearly voluminous. In a two region test run there were 169 pages of output for one period. The MUDEA program, however, contains parameters to control table printing (cf. MOVE, Rees 1984, in which the printing of virtually all tables can be suppressed). The presentation of the results of the multiregional model compares rather unfavourably with that of the UN (Appendix). Time-oriented tables are essential for easy and fruitful use of projection outputs. Tables should be standard for each spatial unit across all spatial scales. The user should be able to suppress difficult to assimilate matrix style multiregional output (really needed only for error diagnosis) and concentrate on the essential results of the multiregional model. All these criticisms apply equally to MOVE.

5.2 The OPCS/DOE subnational population projection model for England

Between 1979 and 1981 a model was developed for the projection of the internal migration component of the official subnational population projections for England by Martin and Voorhees Associates and John Bates Services under contract to the Department of the Environment (DOE) of the United Kingdom in close liaison with the Regional Demography Unit of OPCS. Ian Bracken of the University of Wales Institute of Science and Technology (Cardiff) acted as consultant to the project. The model is fully described in Martin & Voorhees Associates and John Bates Services (1981), in associated programmer's guide and user's manual, and in two journal papers, Bates andd Bracken (1982) and Bracken and Bates (1983). Results of using this new model are reported in the fifth of the series of subnational population projections for England (OPCS 1984). A new set of projections incorporating data from the 1981 Census as well as NHSCR data from the post-1981 period are in course of preparation.

5.2.1 The model

The model is concerned only with internal migration and is designed to supply a pre-existing single region cohort survival model with net migration values by sex and single years of age, values which can be modified in consultation with local authorities, but which were not changed much in the consultation exercise to judge from the comments in OPCS (1984, p.ix). DOE and OPCS were concerned to preserve their existing investment in a subnational projection model. One ironic benefit of using net migration in the projection model is that it doesn't matter whether the net figures are derived from transition or movement data as long as all transition types have been accounted for (Rees 1985).

Since the project brief required that single year of age populations for males, females and persons be projected for 108 local authority areas in England, a fully multiregional strategy was rejected from the outset because of the small number problem. Rather, an approach was developed which used trended gross migration rates, model generated rates of out-migration and in-migration (a "parameterized" strategy) and interregion allocation rates for three broad age groups only.

The model comprises three stages.

(1) The numbers of moves out of each area by age and sex are estimated by applying model migration rates to trended projections of the region-specific Gross Migraproduction Rate (GMR).

(2) These moves are assigned to destinations using a matrix of allocation proportions based on NHSCR migration data for a 5 year period for three broad age groups and two sexes.

(3) The numbers of moves into each area are summed to obtain gross in-migration totals for each area, which are disaggregated by age using model migration rates (as in stage (1) for out-migrants).

It is useful in exposing the structure of the model in full to present it in general equation form (which the authors do not) as this will reveal a number of interesting features. All the variables in the model are disaggregated by sex, but, since the two populations are treated in the same way in the migration model, no notation for the sex classification is introduced in the description below.

(1) <u>The total number of out-migrations</u>

The total number of out-migrations from an area i by age a for a future period t is projected by

$$M^{i.}_{a}(t) = \left(GMR^{i}(t)\ om^{I}_{a}(s) \right) P^{i}_{a}(t) \qquad i \in I \qquad (3)$$

where

$GMR^{i}(t)$ the gross migraproduction rate of out-migration from area i in period t, which is a linear extrapolation of the GMR of the area for a standard period in the past.

$om^{I}_{a}(s)$ the proportion of the out-migration GMR accounted for by age group a. It is derived from model migration rates standardized to a GMR of 1 for area cluster I for standard period s.

$P^{i}_{a}(t)$ = population of region i at age a in period t.

The authors (Bates and Bracken 1982, Bracken and Bates, 1983) used migration data from the 1971 Census to calibrate model migration rate schedules for the 108 areas for males and females. A cluster analysis was then carried out to combine together similar profiles into 12 groups. New model schedules were then defined using the pooled data for the 12 groups.

(2) The assignment of out-migrations to destinations

The total of out-migrations from an area is spread across the available destinations by multiplication by an allocation proportion:

$$M^{ij}_{A}(t) \qquad M^{i.}_{A}(t)\ k^{ij}_{A}(s) \tag{4}$$

where

$M^{ij}_{A}(t)$ = the number of moves from area i to area j in period t in broad age group A

$$M^{i.}_{A}(t) = \sum_{a \varepsilon A} M^{i.}_{a}(t)$$

$k^{ij}_{A}(s)$ = the proportion of origin i moves in broad age group A in standard period s that have destinations in area j.

In OPCS (1984) NHSCR data for mid-1977 to mid-1982, supplemented with 1971 census data where the spatial disaggregation of the NHSCR data was insufficient, were used. The broad age groups were

(i) ages 0-16 and 29-59 (family ages)
(ii) ages 17-28 (labour force ages)
(iii) ages 60 and over (retirement ages).

The broad age groups were determined by the similarity of their origin-destination patterns.

(3) In-migration totals

The inter-area migrations by broad age group were summed and then disaggregated to single years of age:

$$M^{.j}_{a}(t) = \sum_{A} \sum_{j} M^{ij}_{A}(t)\ im^{J}_{a}(s) \tag{5}$$

where

$M^{.j}_{a}(t)$ total number of in-migrations to area j in period t in age group a

$im_a^J(s)$ the proportion of the in-migration GMR accounted for by age group a. The proportions are derived from model migration rates standardized to a GMR of 1 for area cluster J for standard period s.

(4) Net migration

This is then derived as a residual:

$$N_a^j(t) = M_a^{\cdot j}(t) \quad M_a^{j \cdot}(t) \qquad (6)$$

and fed into the single region cohort survival model. Methods were also developed to adjust the migration matrices resulting at stage (2) of the model to exogeneous in-migration totals.

5.2.2 Comments on the OPCS/DOE model

The OPCS/DOE model represents an elegant and thoroughly tested solution to the problem of projecting the internal flows of a large number of subnational areal units, carried out by the consultants in a remarkably short period of 18 months.

However, a number of further comments can be made based on this algebraic reformulation of the model.

Firstly, it is unfortunate that the migration model is decoupled from the population projection model. This means that the indicators of the components of change offered in the projection model output are very limited. Secondly, it would be very easy to carry out this integration and make the combined migration and projection model fully multiregional by merging equations (3) and (4):

$$M_a^{ij}(t) = GMR^i(t) \; om_a^I(s) \; k_A^{ij}(s) \; P_a^i(t) \qquad i \in I, a \in A \qquad (7)$$

or in other words the migration rate would be modelled as

$$m_a^{ij}(t) \quad GMR^i(t) \; om_a^I(s) \; k_A^{ij}(s) \qquad (8)$$

where s refers to the standard or base period (which may differ between variables). Stage (3) of the model is then unnecessary. Constraints on

$M_a^{ij}(t)$ can easily be introduced using multiproportional fitting techniques, generalizations of the Furness method referred to by Martin & Voorhees Associates and John Bates Services (1981).

When we examine the terms on the right hand side of equation (7), it can be seen that the only statistic that is projected forward in time is the GMR. There is no reason why the age factor and the allocation proportion could not also be projected forward given reliable time series, so a more general model would substitute period label t for the standard or base period label s in equations (7) and (8).

A third point to make about the OPCS/DOE model is that, in exposition, it suffers from a lack of clarity as to age-time plan of observation. The subscript a should refer to a period-cohort ATP throughout. However, the NHSCR data are published using the period ATP and Census migration data are collected using the period-cohort ATP. It is also unclear what populations at risk are being used in rate computation: initial, mid-point, average or final populations.

A related fourth point refers to migration concept being used. Both Census and NHSCR data are used (and have to be used) in the model but it is never made clear which conceptual type of migration (movements or transitions) is being estimated and projected. In the exposition above it is assumed that the model works with the movement concept. OPCS 1984, p.viii states that "the level of migration activity" derives from NHSCR data, whereas in the project report (Martin & Voorhees Associates and John Bates Services 1981) the GMRs reported are from census data. This conceptual ambiguity arises from the aim of the model being to generate age disaggregated net migration vectors for areas.

Fifthly, we need to consider the roles of aggregation and sub-model representation in the overall model. The interarea allocation terms, the k's, involve aggregation of actual migration data into a few broad age groups. The alternative of using gravity models of such interarea migration was rejected after investigation because the predicted matrices were felt to be insufficiently accurate. The out-migration factors or om's, involve both aggregation over area cluster and model representation of rates. A great deal of detailed work is involved in the calibration of model migration schedules and their classification though it needs only to be carried out in the British context every ten years. In other situations the use of pooled, observed data to generate standard rates might provide a short cut since the key features of the out-migration rate schedules that vary from area to area (Bracken and Bates, 1983, p.353), namely presence/absence of a retirement peak and/or slope, the age at which the labour force migration peak occurs and the extent to which migration activity is concentrated around the peak could be determined by simpler methods.

How general is the OPCS/DOE model (recalling again the discussion of sections 2.4 and 2.5)? It is clearly a vey specific model in terms of its implementation and exposition, designed for one set of clients (DOE/OPCS) with particular requirements in terms of area populations to be projected. It is also specific in the sense that the aggregation decisions (pooling of out-migration and in-migration profiles by cluster, use of particular broad age bands in allocating out-migration) are peculiar to the system being studied. It is doubtful whether the underlying software would be portable, and the mixture of census and register sources of migration data characteristic of the United Kingdom seems to be repeated only in Japan (Nanjo, Kawashima and Kuroda 1982). However, the methods employed to solve the problem of handling many regions simultaneously are of general utility and could be applied in other contexts.

5.2.3 Outputs

Table 4 summarizes the readily available outputs from the subnational projections. Further detailed data are available from OPCS's Regional Demography Unit. Output tables 1 to 4 appear in OPCS (1984); tables 5 and 6 are the standard detailed projection tables provided on request.

A good feature of these outputs is their time orientation, although the published tables are woefully inadequate in the number of future time points for which data are provided - only two! For any serious use of these projections the user needs to obtain the detailed single years of age and time outputs from the Regional Demography Unit. Output tables 3 and 4 provide some idea of the components in number form but not in rate form. Summary indicators such as GMRs or total fertility rates or life expectancies are not provided.

As with the MUDEA model, the outputs of the OPCS/DOE model are not as well organized and accessible as those of the United Nations' projections (Appendix).

6. CONCLUSIONS

The purpose of this review has been to look critically at these two new applications of multiregional methods in order to learn from the experience. Here an attempt is made to summarize what has been learnt.

The theoretical base and mathematical specification of the Dutch MUDEA model are very sound. The projection model is carefully matched with the movement type of migration data used in a period-cohort age-time plan. The English OPCS/DOE model is not as well specified as one set of equations, and there is a lack of clarity concerning both the migration concept aimed at in the model and the age-time plans employed. However, it has the merit of making fruitful use of both census and register derived migration data, using the former to overcome deficiencies in the latter.

The Dutch MUDEA model is a multiregional model that handles all migration flows in age-sex-origin-destination specificity with a considerable degree of flexibility. So, for example, projections of the 11 provinces or of . 15 functional regions or 41 urbanization regions could be carried out. The English OPCS/DOE model involves modelling of pooled profiles of out- and in-migration at a detailed age scale and an age pooled method of assigning out-migration to destinations. It is designed to prepare the migration projections for 108 areas and is capable of handling the other subnational areas of the United Kingdom outside England as well either separately or together with those of England.

Whereas the Dutch model is easily portable to other demographic systems for which the same kinds of data are available, it is difficult to envisage the English model being directly used because of some system specific features. These are the need to arrive at a classification of in- and out-migration profiles and a pooling of the age specific interarea migration matrices into broad age ranges with common interaction features. The classes and age ranges will vary from situation to situation. Nevertheless the ideas behind the English model could well be applied elsewhere because it provides a solution to the problem of using multiregional models with a large number of regions.

In terms of user requirements both models provide the essential projections by single year of age and sex of the populations of subnational units, controlled by sets of time-varying assumptions as to levels of fertility, mortality and migration, and thus represent considerable advances on previous models and software. The organization and presentation of the results of both models, however, fall short of the ideal. The MUDEA model provides voluminous outputs on a single year of age basis for both inputs and results, and it is difficult for users to find the essential statistics amid the haystack of paper. Output tables are provided a year at a time, whereas most users find tabulations of statistics across time points or intervals much easier to contemplate and from which trends can be grasped more easily. A time orientation is employed in the presentation of the results of the English area projections, but the published volume provides very little information at the level of detail on the key statistics input to each time interval. Users must purchase detailed unpublished tabulations and tapes. The outputs of both Dutch and English models contrast unfavourably with the projection statistics published by the UN (Appendix) for countries of the world. Such a volume and associated tapes, with appropriate modifications, for the subnational areas of the Netherlands and the United

Kingdom would be a very valuable planning and research resource.

These efforts in the application of multiregional methods to official subnational population projection represent considerable pioneering achievements. There is ample room, however, for improvement in the "packaging" of both models and outputs: the field awaits its Alan Sugar (the boss of the Amstrad company, who repackaged consumer electronics, word processors and business machines and made a fortune).

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Table 1. Transition accounts and associated rates for Great Britain, 1966-71, age transition 20-24 to 25-29, persons.

Final state / Initial state		Survival in: Aged 25-29				Death in: Aged 20-24 or 25-29				Totals
		EA	SE	RB	RW	EA	SE	RB	RW	
Existence in: Aged 20-24	East Anglia (EA)	79,620 (.78826)	7,578 (.07502)	8,141 (.08060)	5,296 [.05243]	334	13	15	10	101,007
	South East (SE)	14,408 (.01217)	984,059 (.83111)	79,740 (.06735)	101,985 [.08596]	26	3,691	148	175	1,184,032
	Rest of Britain (RB)	9,440 (.00413)	84,510 (.03700)	2,074,448 (.90813)	107,473 [.04703]	18	145	8,056	208	2,284,298
	Rest of World (RW)	7,790 {.07712}	88,045 {.07436}	70,123 {.03070}	0	14	149	134	0	166,255
	Totals	111,258	1,164,192	2,232,452	214,554	392 <.00369>	3,998 <.00341>	8,353 <.00370>	393	3,735,592

Source: Rees (1979b)

(.78826) internal survivorship rates	[.05243] emigration rates
{.07712} immigration rates	<.00370> non-survivorship rates or death rates

Table 2. Movement accounts and associated rates for the Netherlands, 1976, age transition 20 to 21, females.

Final state / Initial state	State after move				Totals
	WN	RN	RW	Deaths	
West Netherlands (WN)	49,121	1,375 (.02682)	402 [.00784]	17 (.00033)	50,915
Rest of the Netherlands (RN)	1,739 (.02821)	59,595	437 [.00709]	23 (.00037)	61,794
Rest of world (RW)	759 {.01480}	546 {.00886}	0 -	0 -	1,305
Totals	51,619	61,516	839	40	114,014

Notes

1. West Netherlands consists of the provinces of Noord-Holland, Zuid-Holland and Utrecht. The Rest of the Netherlands contains the remaining 8 provinces and Ijsselmeerpolder.

2. Rates:-

(0.2682) internal movement rates

[.00784] emigration rates

{.01480} immigration rates

All rates employ an average population at risk.

TABLE 3. Summary of the output tables produced by MUDEA

TABLE	VARIABLES	FORM	MACRO-CLASS	ROW-CLASS	COLUMN-CLASS
1.	population (initial)	numbers percentages	Sex	Age (1)	region
2.	population (initial)	numbers percentages	Sex	Age (5)	region
3.	person/years, births, deaths, interregional migration, external migration	numbers percentages	Sex by region	Age (1)	components (as under variables)
4.	person years, births, deaths interregional migration, external migration	numbers percentages	Sex by region	Age (5)	components (as under variables)
5.	components as in 4 (except person years)	age specific rates per 1000	Sex by region	Age (1)	components (as under variables)
6.	components as in 5	age specific rates per 1000	Sex by region	Age (5)	components (as under variables)
7.	components (summarized)	numbers, percentages years rates per 1000 mid-year population		sex by region	components
8.	birth rates	age-specific rates	Sex by origin region	Age (1)	destination region
9.	survivorship rates	age-specific rates (decimal proportions)	Sex by origin region	Age (1)	destination region
10.	internal migration	numbers	Sex by origin region	Age (1)	destination region
11.	internal migration	numbers	Sex by origin region	Age (5)	destination region
12.	internal migration	percentages	Sex by origin region	Age (1)	destination region
13.	internal migration	percentages	Sex by origin region	Age (5)	destination region
14.	internal migration	rate per 1000 (out-migration)	Sex by origin region	Age (1)	destination region
15.	internal migration	rate per 1000 (out-migration)	Sex by origin region	Age (5)	destination region
16.	internal migration (summarized)	numbers, percentages, rates	Sex	form by origin region	destination region
17.	population (final)	numbers, percentages	Sex	Age (1)	residence region
18.	population (final)	numbers, percentages	Sex	Age (5)	residence region

Notes to Table 3

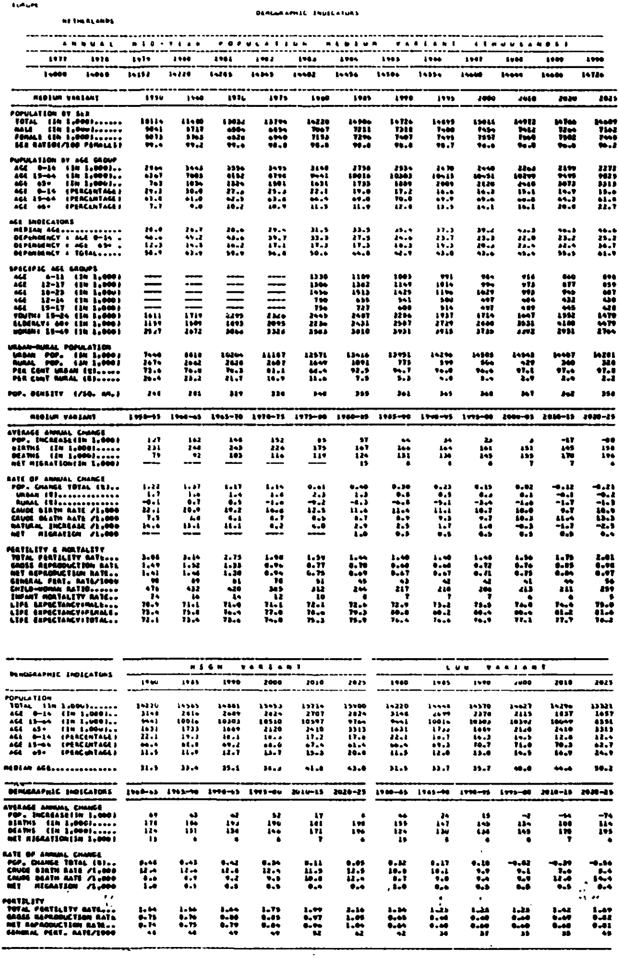
1. Percentages = age-specific variable as % of all age total
2. Table 8: the column class in the MUDEA output is incorrectly labelled as "birth region": it is the region of destination of the infant
3. Table 10 includes migration between localities within regions which do not figure in the MUDEA model as such
4. Age (1) = single years of age age (5) = 5 year age groups

TABLE 4 Summary of the output tables produced by the OPCS/DOE model

TABLE	VARIABLES	MACRO-CLASS	ROW-CLASS	COLUMN CLASS
1	populations (mid-year projected)	England regions	age (5) ages (summary)	time by sex
2	populations (mid-year projected)	Areas (see note 3)	time by sex	ages (summary
3	natural components (births, deaths natural change)		Areas (see note 3)	components (as variables), two summary time periods
4	projected in-out and net migration		Areas (as in 3)	migration components (as variables) two summary time periods
5	populations (mid-year projected)	Areas (as in 3)	age (1)	time (years) by sex
6	populations (mid-year projected)	Areas (as in 3)	age (5)	time (years) by sex

Notes

Tables 1 to 4 appear in OPCS (1984) and report on population projections from 1981 to 2001.
Tables 5 and 6 are examples of unpublished tabulations obtained from the Regional Demography Unit (Dept. ARV), Office of Population Censuses and Surveys St. Catherines House, 10 Kingsway, London WC2B 6JP. Populations to 2011 are provided
Areas: Table 2: Inner London boroughs, Outer London boroughs, Metropolitan Counties and Districts, Non-Metropolitan Counties
Table 3: England, standard regions, and Table 2 areas



APPENDIX

TABLE A.1 Demographic indicators, Netherlands (from UN, 1985)

POPULATION (IN THOUSANDS) BY SEX AND AGE, MEDIUM VARIANT

NETHERLANDS

AGE GROUP	1950			1955			1960			1965		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	10114	5041	5073	10751	5356	5395	11480	5717	5763	12292	6133	6159
0-4	1207	620	587	1110	570	540	1154	591	563	1215	622	593
5-9	932	476	456	1186	609	577	1106	568	538	1152	590	562
10-14	885	481	404	918	470	448	1183	607	576	1107	568	539
15-19	811	414	397	817	416	401	913	467	446	1183	606	577
20-24	800	404	396	790	401	389	806	410	396	912	468	444
25-29	796	395	401	747	363	384	771	390	381	806	413	393
30-34	689	341	348	773	380	393	756	376	380	774	395	379
35-39	683	335	348	675	333	342	765	375	390	757	378	379
40-44	650	317	333	670	328	342	669	329	340	763	375	388
45-49	593	289	304	637	310	327	662	323	339	663	325	338
50-54	520	252	268	579	281	298	625	303	322	650	316	334
55-59	449	218	231	503	242	261	561	270	291	604	289	315
60-64	376	183	193	424	204	220	475	225	250	529	249	280
65-69	305	148	157	343	165	178	387	182	205	431	190	241
70-74	231	111	120	259	124	135	293	138	155	331	151	180
75-79	145	69	76	173	82	91	196	91	105	224	102	122
80+	102	46	56	127	58	69	156	72	84	169	64	105

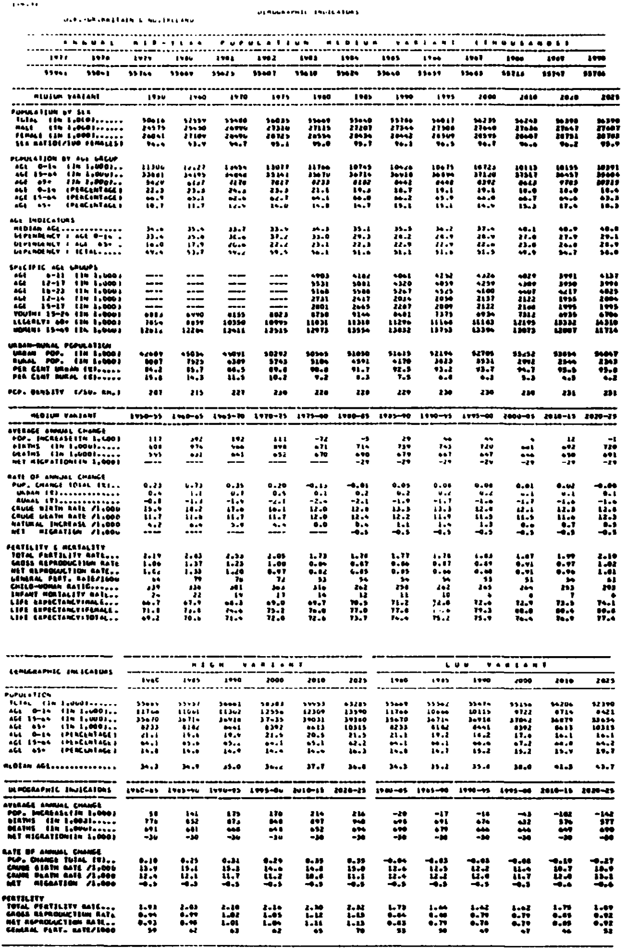
AGE GROUP	1970			1975			1980			1985		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	13032	6504	6528	13794	6854	6940	14220	7067	7153	14507	7211	7296
0-4	1188	608	580	1038	531	507	875	449	426	827	423	404
5-9	1214	621	593	1215	622	593	1047	535	512	878	451	427
10-14	1155	591	564	1242	635	607	1226	627	599	1052	537	515
15-19	1110	568	542	1184	604	580	1252	640	612	1231	629	602
20-24	1184	608	576	1142	583	559	1193	608	585	1256	641	615
25-29	916	477	439	1212	626	586	1150	587	563	1196	609	587
30-34	813	423	390	933	487	446	1219	629	590	1153	587	566
35-39	775	397	378	825	428	397	938	489	449	1220	629	591
40-44	754	377	377	773	390	383	828	429	399	936	486	450
45-49	754	369	385	753	374	379	780	396	384	824	426	398
50-54	660	317	343	745	361	384	746	367	379	771	389	382
55-59	627	301	326	631	302	329	729	349	380	729	355	374
60-64	569	266	303	594	274	320	605	284	321	696	326	370
65-69	479	217	262	520	228	292	550	246	304	560	255	305
70-74	366	160	206	420	175	245	453	190	263	481	206	275
75-79	254	109	145	285	120	165	330	129	201	358	141	217
80+	225	96	129	276	106	170	297	111	186	335	119	216

AGE GROUP	1990			1995			2000			2005		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	14726	7319	7407	14895	7400	7495	15011	7454	7557	15025	7453	7572
0-4	825	422	403	814	417	397	797	408	389	748	383	365
5-9	828	423	405	826	422	404	815	417	398	796	406	390
10-14	880	451	429	830	424	406	828	423	405	816	417	399
15-19	1052	536	516	882	452	430	831	424	407	829	423	406
20-24	1232	629	603	1055	538	517	883	452	431	832	424	408
25-29	1256	640	616	1233	628	605	1056	537	519	884	452	432
30-34	1196	610	586	1257	640	617	1233	628	605	1056	536	520
35-39	1153	586	567	1196	606	590	1257	639	618	1232	626	606
40-44	1217	626	591	1151	584	567	1193	604	589	1254	636	618
45-49	932	482	450	1210	620	590	1144	578	566	1188	599	589
50-54	813	417	396	920	473	447	1195	608	587	1131	568	563
55-59	752	375	377	794	403	391	898	457	441	1167	587	580
60-64	680	335	345	720	352	368	761	379	382	861	430	431
65-69	647	294	353	647	299	348	669	317	352	707	341	366
70-74	490	213	277	567	246	321	569	251	318	587	266	321
75-79	380	152	228	390	159	231	452	186	266	454	188	266
80+	372	128	244	406	140	266	431	149	282	480	167	313

AGE GROUP	2010			2015			2020			2025		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	14972	7412	7560	14880	7346	7534	14766	7264	7502	14610	7162	7448
0-4	715	366	349	721	369	352	768	389	379	706	362	344
5-9	749	383	366	716	367	349	722	370	352	761	390	371
10-14	799	408	391	750	383	367	717	367	350	723	370	353
15-19	818	418	400	801	409	392	751	384	367	718	367	351
20-24	830	423	407	818	417	401	801	409	392	752	386	366
25-29	833	424	409	830	424	406	819	418	401	801	408	393
30-34	884	452	432	833	424	409	830	422	408	819	417	402
35-39	1056	536	520	884	451	433	833	423	410	830	422	408
40-44	1230	624	606	1055	535	520	882	449	433	832	422	410
45-49	1248	631	617	1225	620	605	1050	530	520	879	446	433
50-54	1174	589	585	1234	620	614	1212	609	603	1040	524	516
55-59	1107	550	557	1149	570	579	1209	601	608	1188	591	597
60-64	1121	555	566	1065	519	546	1107	539	568	1166	569	597
65-69	802	386	416	1047	501	546	996	471	525	1037	490	547
70-74	624	288	336	710	329	381	928	425	503	887	401	486
75-79	472	201	271	503	218	285	574	250	324	754	324	430
80+	511	179	332	540	192	348	575	209	366	634	234	400

APPENDIX

TABLE A.2 Population (in 1000s) by age and sex, medium variant (from UN, 1985), Netherlands



APPENDIX

TABLE A.3 Demographic indicators, United Kingdom (from UN, 1985)

POPULATION (IN THOUSANDS) BY SEX AND AGE, MEDIUM VARIANT

U.K.-GR.BRITAIN & NO.IRELAND

AGE GROUP	1950			1955			1960			1965		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	50616	24575	26041	51199	24726	26473	52559	25450	27109	54520	26516	28004
0-4	4347	2225	2122	3854	1975	1879	4150	2126	2024	4756	2440	2316
5-9	3611	1843	1768	4198	2193	2005	3806	1949	1857	4114	2109	2005
10-14	3348	1702	1646	3570	1823	1747	4263	2180	2083	3795	1940	1855
15-19	3316	1675	1641	3312	1669	1643	3585	1824	1761	4287	2191	2096
20-24	3567	1801	1766	3294	1654	1640	3405	1725	1680	3681	1867	1814
25-29	3879	1953	1926	3461	1730	1731	3303	1672	1631	3432	1747	1685
30-34	3498	1755	1743	3613	1695	1918	3430	1716	1714	3337	1711	1626
35-39	3891	1936	1955	3385	1667	1718	3773	1872	1901	3427	1731	1696
40-44	3857	1909	1948	3784	1860	1924	3350	1647	1703	3766	1870	1896
45-49	3565	1732	1833	3737	1840	1897	3716	1822	1894	3300	1625	1675
50-54	3142	1660	1482	3467	1675	1792	3619	1765	1854	3606	1747	1859
55-59	2741	1236	1505	2949	1341	1608	3292	1568	1724	3439	1650	1789
60-64	2425	1078	1347	2514	1095	1419	2722	1206	1516	3036	1406	1630
65-69	2057	894	1163	2109	888	1221	2212	914	1298	2381	994	1387
70-74	1592	678	914	1667	676	991	1725	676	1049	1809	694	1115
75-79	1032	428	604	1135	441	694	1197	444	753	1250	440	810
80+	748	270	478	860	304	556	1005	336	669	1104	344	760

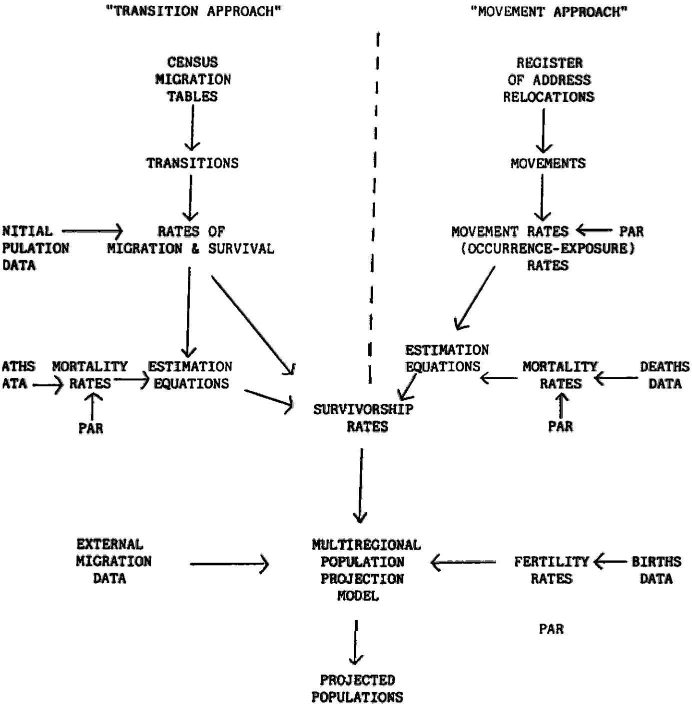
AGE GROUP	1970			1975			1980			1985		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	55480	26990	28490	56035	27310	28725	55669	27115	28554	55640	27207	28434
0-4	4507	2311	2196	3954	2035	1919	3400	1748	1652	3492	1787	1705
5-9	4899	2609	2290	4498	2309	2189	3903	2008	1895	3362	1727	1635
10-14	4248	2182	2066	4625	2373	2252	4463	2291	2172	3890	2004	1886
15-19	3882	1991	1891	4145	2128	2017	4616	2368	2248	4522	2319	2203
20-24	4273	2165	2108	3878	1982	1896	4142	2126	2016	4622	2366	2256
25-29	3703	1878	1825	4196	2127	2069	3803	1934	1869	4062	2094	1968
30-34	3294	1694	1600	3476	1765	1711	4102	2060	2042	3739	1892	1847
35-39	3157	1595	1562	3253	1653	1600	3406	1740	1666	4059	2031	2028
40-44	3305	1650	1655	3159	1592	1567	3190	1615	1575	3369	1695	1674
45-49	3500	1730	1770	3292	1637	1655	3086	1549	1537	3136	1577	1559
50-54	3268	1592	1676	3535	1735	1800	3177	1565	1612	3008	1499	1509
55-59	3334	1603	1731	3029	1454	1575	3352	1621	1731	3047	1477	1570
60-64	3172	1483	1689	3170	1480	1690	2798	1311	1487	3128	1469	1659
65-69	2681	1182	1499	2831	1262	1569	2810	1260	1550	2531	1144	1387
70-74	1984	764	1220	2212	899	1313	2313	943	1370	2354	975	1379
75-79	1278	448	830	1446	496	950	1641	596	1045	1745	628	1117
80+	1235	361	874	1328	375	953	1469	402	1067	1581	548	1033

AGE GROUP	1990			1995			2000			2005		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	55786	27344	28442	56017	27508	28509	56235	27640	28595	56256	27654	28602
0-4	3620	1852	1768	3646	1866	1780	3540	1812	1728	3345	1712	1633
5-9	3456	1767	1689	3586	1835	1751	3410	1647	1763	3504	1793	1711
10-14	3350	1724	1626	3445	1765	1680	3573	1831	1742	3600	1845	1755
15-19	3951	2034	1917	3413	1755	1658	3507	1795	1712	3636	1862	1774
20-24	4530	2319	2211	3962	2035	1927	3426	1759	1667	3521	1800	1721
25-29	4563	2335	2228	4473	2289	2184	3907	2007	1900	3372	1732	1640
30-34	4019	2055	1964	4500	2293	2207	4412	2249	2163	3848	1969	1879
35-39	3700	1866	1834	3981	2027	1954	4403	2208	2195	4375	2224	2151
40-44	4023	2007	2016	3669	1845	1824	3952	2007	1945	4433	2246	2187
45-49	3320	1661	1659	3978	1978	2000	3625	1813	1812	3909	1974	1935
50-54	3065	1532	1533	3249	1614	1635	3695	1920	1775	3560	1768	1792
55-59	2893	1419	1473	2956	1455	1501	3143	1539	1604	3775	1832	1943
60-64	2855	1344	1511	2720	1298	1422	2791	1337	1454	2975	1416	1559
65-69	2813	1257	1556	2580	1158	1422	2470	1126	1344	2544	1164	1380
70-74	2111	870	1241	2391	991	1400	2209	922	1287	2123	900	1223
75-79	1791	658	1133	1622	595	1026	1854	688	1166	1723	644	1079
80+	1727	646	1080	1854	717	1136	1859	721	1138	2013	775	1238

AGE GROUP	2010			2015			2020			2025		
	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES	BOTH SEXES	MALES	FEMALES
ALL AGES	56243	27636	28607	56302	27637	28665	56398	27647	28751	56390	27607	28783
0-4	3309	1694	1615	3405	1744	1661	3522	1806	1716	3546	1818	1728
5-9	3310	1693	1617	3274	1675	1599	3370	1725	1645	3467	1766	1701
10-14	3494	1791	1703	3300	1691	1609	3263	1673	1590	3360	1723	1637
15-19	3643	1876	1767	3557	1822	1735	3364	1723	1641	3327	1705	1622
20-24	3650	1946	1704	3677	1881	1796	3571	1827	1744	3379	1729	1650
25-29	3467	1772	1695	3596	1839	1757	3625	1856	1769	3518	1801	1717
30-34	3514	1894	1620	3409	1735	1674	3538	1802	1736	3565	1817	1748
35-39	3813	1945	1868	3281	1672	1609	3377	1714	1663	3509	1780	1729
40-44	4347	2203	2144	3788	1927	1861	3299	1696	1603	3355	1699	1656
45-49	4388	2212	2176	4304	2170	2134	3750	1899	1851	3247	1652	1595
50-54	3840	1926	1914	4315	2160	2155	4235	2122	2113	3692	1856	1836
55-59	3494	1690	1804	3729	1843	1886	4194	2070	2124	4120	2036	2084
60-64	3581	1690	1891	3352	1642	1710	3546	1708	1838	3995	1922	2073
65-69	2720	1257	1463	3403	1601	1802	3012	1372	1640	3262	1505	1757
70-74	2193	934	1259	2353	997	1356	2850	1199	1651	2621	1116	1505
75-79	1668	638	1030	1722	659	1063	1855	708	1146	2259	857	1402
80+	2039	780	1259	2030	777	1253	2068	790	1278	2173	825	1348

APPENDIX

TABLE A.4 Population (in 1000's) by age and sex, medium variant (from UN, 1985), United Kingdom



KEY

PAR POPULATION AT RISK (MID-INTERVAL OR AVERAGE POPULATION)

FIGURE 1 The steps in the incorporation of migration data in regional population projections

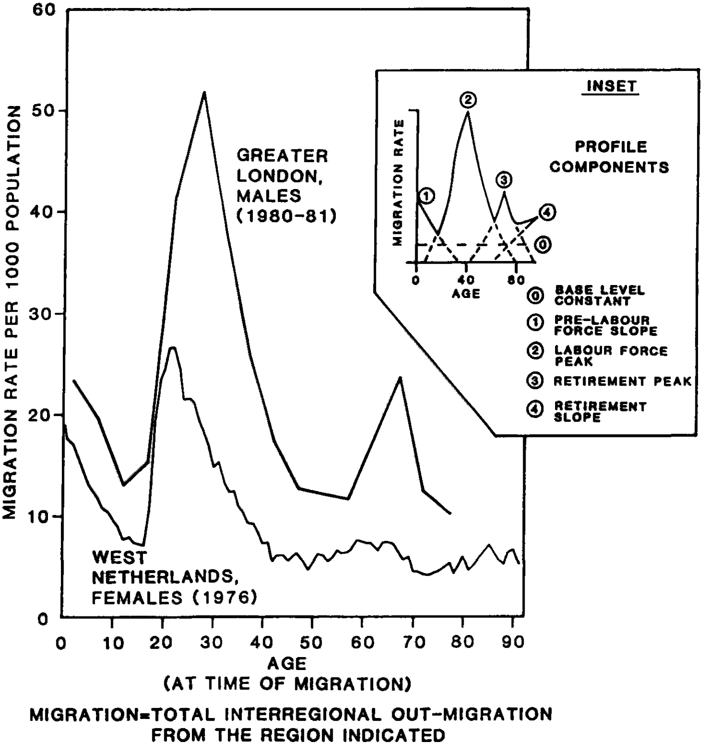


FIGURE 2. Examples of migration rate profiles

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