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MULTISTATE DEMOGRAPHIC ACCOUNTS: MEASUREMENT AND ESTIMATION PROCEDURES

Philip H. Rees

School of Geography,
University of Leeds,
Leeds LS2 9JT
U.K.

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Contents

Abstract

Accounting frameworks developed in the field of economics are applied to the problem of measuring changes-in-state of populations. Examples of accounts in the educational sector, in the job market and in a regional system are described.

Proper estimation of multistate demographic accounts involves attention to data sources, much initial estimation of variables, construction of a model to estimate missing items and use of the possible constraints on the accounts matrix. These steps in accounts estimation are illustrated for a set of accounts for British regions for 1970-76. Data are assembled for a base period 1970-71. Alternative methods of constructing accounts are tested by running the estimation model in projective mode for 1971-76. One method is selected and used to complete the set of accounts.

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Tables

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2. What are multistate demographic accounts?

2.1 General definitions

Accounts are arrangements of statistics in matrix or tabular form. Demographic accounts are such matrices or tables that involve either people or events connected with them. The adjective "multistate" implies that there is concern with the transition of people among many states. Those states might be "ages", amongst which there is a well ordered set of transitions with most transitions being impossible. Or the states might be educational grades, closely related to, but not the same as, ages. At least some of the states in accounts involve geographical areas.

Accounts matrices have two dimensions. The first, say the rows, represent the states of the population initially, and the second, the columns, the states of the population finally, after the transitions or movements have occurred.

A variety of entities may be represented in accounts: people, pupils, unemployment spells, houses, households, job holders, migrations, marriages and divorces, and time are but a few. A selection of accounts containing some of these different entities is presented below.

2.2 Simple components of growth accounts

The very simplest type of accounts involves the arrangement of the terms in the components of growth equation:

$$P^i(t+T) = P^i(t) + NI^i(t,t+T) + NM^i(t,t+T) \qquad (1)$$

where P^i refers to the population in region i at the start of the period, time t, or at the end, time t+T, T being the length of the period in years. The terms NI^i and NM^i refer to natural increase in region i and net migration into region i respectively. The first portion of Table 1 (subtable 1.1) shows such a set of accounts for sections of Great Britain in 1970-71.

The natural increase term in Equation (1) is usually further decomposed into constituent birth and death terms:

$$P^i(t+T) = P^i(t) + B^i(t,t+T) - D^i(t,t+T) + NM^i(t,t+T) \qquad (2)$$

Table 1. Accounts based on the components-of-growth equations aggregate regions, G. Britain, 1970-71
(Figures in 1000s)

Table 1.1

Section	Final population	Initial population	Natural increase	Net migration
NORTH	14607.7	14576.0	61.0	-29.4
MIDLANDS	8756.1	8700.0	54.7	1.4
SOUTH	22767.0	22687.0	88.8	- 8.9
CELTIC FRINGE	7941.0	7930.7	32.3	-22.0
G. BRITAIN	54071.8	53893.7	236.8	-58.9

Table 1.2

Section	Final population	Initial population	Births	Deaths	Net migration
NORTH	14607.7	14576.0	241.5	180.5	-29.4
MIDLANDS	8756.1	8700.0	149.2	94.5	1.4
SOUTH	22767.0	22687.0	350.1	261.3	- 8.9
CELTIC FRINGE	7941.0	7930.7	129.8	97.5	-22.0
G. BRITAIN	54071.8	53893.7	870.6	633.8	-58.9

Table 1.3

Section	Final population	Initial population	Births	Deaths	In-migrants	Out-migrants
NORTH	14607.7	14576.0	241.5	180.5	206.7	236.1
MIDLANDS	8756.1	8700.0	149.2	94.5	182.1	180.7
SOUTH	22767.0	22687.0	350.1	261.3	442.6	451.5
CELTIC FRINGE	7941.0	7930.7	129.8	97.5	130.1	152.1
G. BRITAIN	54071.8	53893.7	870.6	633.8	384.4	443.3

Table 1.4

Section	Final population	Initial population	Births	Deaths	In-migrants		Out-migrants	
					Int.	Ext.	Int.	Ext.
NORTH	14607.7	14576.0	241.5	180.5	145.6	61.1	153.0	83.1
MIDLANDS	8756.1	8700.0	149.2	94.5	139.9	42.2	128.6	52.1
SOUTH	22767.0	22687.0	350.1	261.3	199.3	243.3	203.4	248.1
CELTIC FRINGE	7941.0	7930.7	129.8	97.5	92.1	38.0	92.2	59.9
G. BRITAIN	54071.8	53893.7	870.6	633.8	-	384.4	-	443.3

where B^i refers to the total of births in region i and D^i to the total of deaths. Table 1.2 shows this decomposition for the sections of Great Britain. Similar accounts are published for the countries of the U.K. (England, Wales, Scotland, Northern Ireland) by O.P.C.S. (1975-79), and such tables have been estimated for 1965-76 for the standard regions (post-April, 1974 definitions) in Rees (1978).

Further deconsolidation of the net migration term is often desirable into the separate inflow and outflow components:

$$P^i(t+T) = P^i(t) + B^i(t,t+T) - D^i(t,t+T) + M^{Ri}(t,t+T) - M^{iR}(t,t+T) \quad (3)$$

where $M^{Ri}(t,t+T)$ are the migrations from the rest of the world, R, into region i in the period, and $M^{iR}(t,t+T)$ are the migrations out of the region i to the rest of the world, R.

The terms in Equation (3) are all counts of moves (made by persons) rather than counts of persons. In case of births and deaths the moves counts and the persons counts are numerically identical, but this is not true for the migration terms. Equation (3) can be re-expressed in person terms by adopting a slightly different notation:

$$K^{*(*)\sigma(i)}{}_{(t+T)} = K^{\epsilon(i)*(*)}{}_{(t)} + K^{\beta(i)*(*)}{}_{(t,t+T)} - K^{*(*)\delta(i)}{}_{(t,t+T)} + K^{*(R)*(i)}{}_{(t,t+T)} - K^{*(i)*(R)}{}_{(t,t+T)} \quad (4)$$

The letter K denotes persons and each variable in the equation is different kind of person count. $K^{*(*)\sigma(i)}{}_{(t+T)}$ are those surviving, σ, in region i at t+T; $K^{\epsilon(i)*(*)}{}_{(t)}$ are those in existence, ϵ, in region i, at time t; $K^{\beta(i)*(*)}{}_{(t,t+T)}$ are the total number of persons born in region i in the period t to t+T; $K^{*(*)\delta(i)}{}_{(t,t+T)}$ are the total number of persons dying in the period t to t+T; $K^{*(R)*(i)}{}_{(t,t+T)}$ are the total number of persons initially located in the rest of the world and finally located in region i in the period; and $K^{*(i)*(R)}{}_{(t,t+T)}$ are persons is the reverse situation. The asterisks denote summation over the superscripts which they replace, so that

$$K^{*(R)*(i)} = K^{\epsilon(R)\sigma(i)} + K^{\epsilon(R)\delta(i)} + K^{\beta(R)\sigma(i)} + K^{\beta(R)\delta(i)} \quad (5)$$

and

$$K^{*(i)*(R)} = K^{\epsilon(i)\sigma(R)} + K^{\epsilon(i)\delta(R)} + K^{\beta(i)\sigma(R)} + K^{\beta(i)\delta(R)} \quad (6)$$

Table 1.3 illustrates accounts based on Equation (4) with in- and out-migrants distinguished. Note that small net migration figures as in the South can mask very large inflows and outflows.

The migration terms in Equations (3) and (4) are explicitly related in the following way:

$$M^{Ri}(t,t+T) = K^{*(R)*(i)}(t,t+T) + M^{Ri}_{SUR}(t,t+T) \quad (7)$$

and

$$M^{iR}(t,t+T) = K^{*(i)*(R)}(t,t+T) + M^{iR}_{SUR}(t,t+T) \quad (8)$$

where

$$M^{Ri}_{SUR}(t,t+T) = M^{iR}_{SUR}(t,t+T) \quad (9)$$

The terms M^{Ri}_{SUR} and M^{iR}_{SUR} refer to migrations surplus to those required to accomplish the transition of persons from initial to final states within a period. The equality of Equation (9) only holds for the sum of surplus migrations to and from a region i rather than for surplus migrations between region i and any other region.

It is often crucial to distinguish those in- and out-migrant streams originating or having their destination in the same country as the region of interest from those originating or having their destination in the outside world. If this is done than Equation (4) becomes further disaggregated into:

$$K^{*(*)\sigma(i)}_{(t+T)} = K^{\epsilon(i)*(*)}_{(t)} + K^{\beta(i)*(*)}_{(t,t+T)} - K^{*(*)\delta(i)}_{(t,t+T)} + \sum_{j\in I} K^{*(j)*(i)}_{(t,t+T)} - \sum_{j\in I} K^{*(i)*(j)}_{(t,t+T)} + \sum_{j\in E} K^{*(j)*(i)}_{(t,t+T)} - \sum_{j\in E} K^{*(i)*(j)}_{(t,t+T)} \quad (10)$$

where I refers to the internal set of regions (those inside the country containing region i) and E to the external set of regions. Table 1.4 shows the components of growth accounts with this added disaggregation. The importance of external migration flows is very clear, and in the case of the South (East Anglia, South East and South West) the external flows exceed those from the rest of the country.

Simple components of growth accounts can be rearranged to show the inflows to and outflows from a region in a time period:

$$K^{*(*)\sigma(i)}_{(t+T)} + K^{*(*)\delta(i)}_{(t,t+T)} + K^{*(i)*(R)}_{(t,t+T)} = K^{\epsilon(i)*(*)}_{(t)} + K^{\beta(i)*(*)}_{(t,t+T)} + K^{*(R)*(i)}_{(t,t+T)} \quad (11)$$

The left hand side of Equation (11) contains the outflow terms - final population, deaths and out-migrants - and the right hand side contains the inflow terms - initial population, births and in-migrants. Table 2 rearranges the Table 1 figures in the form of Equation (11). The inflow or outflow total for a region represents the total of persons existing in, entering or leaving a region over a period and is a more valid measure of the demands made by the population than are the initial or final stock figures, although it would be better to weight the various flows by the time they spend in the region.

2.3 Open, period to period, accounts

Simple components of growth accounts were first extended by Richard Stone (Stone, 1965, 1966, 1971a, 1971b, 1975) for several periods taken together in what he calls "open" accounts. The elements of the components of growth equation (in the form of Equation (4), for example) are arranged for a sequence of years. Table 3 shows how this can be

Table 2. Inflow-outflow accounts for aggregate regions, Britain, 1970-71

Flows into and out of 1970-71	NORTH	MIDLANDS	SOUTH	CELTIC FRINGE	G. BRITAIN
INFLOWS					
Initial populations	14576.0	8700.0	22687.0	7930.7	53893.7
Births	241.5	149.2	350.1	129.8	870.6
In-migrants	206.7	182.1	442.6	130.1	384.4
Totals	15024.2	9031.3	23479.7	8190.6	55148.7
OUTFLOWS					
Deaths	180.5	94.5	261.3	97.5	633.8
Out-migrants	236.1	180.7	451.5	152.1	443.3
Final populations	14607.7	8756.1	22767.0	7941.0	54071.8
Totals	15024.3	9031.3	23479.8	8190.6	55148.9

Notes

1. Source: Table 1. The slight discrepancy between the totals of inflows and the totals of outflows is due to rounding.

Table 3. Open, year to year, accounts for aggregate regions, Britain, 1970-73

Inputs \ Outputs		Deaths	Out-migrants	Population 1971-72 N	M	S	C	Population 1972-73 N	M	S	C	Totals
Births				230.0	143.0	338.7	124.0	210.4	132.6	317.7	115.2	
In-migrants				202.3	184.6	447.0	129.8	201.1	183.2	449.1	139.6	
Population 1970-71	North	180.5	236.1	14607.7								15024.3
	Midlands	94.5	180.7		8756.1							9031.3
	South	261.3	451.5			22767.0						23479.8
	Celtic Fringe	97.5	152.1				7941.0					8190.6
Population 1971-72	North	183.1	229.6					14627.2				15039.9
	Midlands	96.2	172.3						8815.2			9083.7
	South	264.5	426.9							22861.3		23552.7
	Celtic Fringe	98.8	151.1								7945.0	8194.8
Totals				15040.0	9083.7	23552.7	8194.8	15038.7	9131.0	23628.1	8199.8	

Table 4. Open, year to year, accounts: symbolic representation for a two region system of interest

Inputs \ Outputs			Deaths	Out-migrants	Population: Period θ, Region 1	Population: Period θ, Region 2	Population: Period θ+1, Region 1	Population: Period θ+1, Region 2	Totals
Births					$K^{\beta(1)*(*)}(\theta)$	$K^{\beta(2)*(*)}(\theta)$	$K^{\beta(1)*(*)}(\theta+1)$	$K^{\beta(2)*(*)}(\theta+1)$	
In-migrants					$K^{*(R)*(1)}(\theta)$	$K^{*(R)*(2)}(\theta)$	$K^{*(R)*(1)}(\theta+1)$	$K^{*(R)*(2)}(\theta+1)$	
Population	Period θ-1	Region 1	$K^{*(*)\delta(1)}(\theta-1)$	$K^{*(1)*(R)}(\theta-1)$	$K^{*(*)\sigma(1)}(\theta-1)$ or $K^{\epsilon(1)*(*)}(\theta)$				$K^{*(*)*(*)}(1)\ (\theta-1)$
		Region 2	$K^{*(*)\delta(2)}(\theta-1)$	$K^{*(2)*(R)}(\theta-1)$		$K^{*(*)\sigma(2)}(\theta-1)$ or $K^{\epsilon(2)*(*)}(\theta)$			$K^{*(*)*(*)}(2)\ (\theta-1)$
	Period (θ)	Region 1	$K^{*(*)\delta(1)}(\theta)$	$K^{*(1)*(R)}(\theta)$			$K^{*(*)\sigma(1)}(\theta)$ or $K^{\epsilon(1)*(*)}(\theta+1)$		$K^{*(*)*(*)}(1)\ (\theta)$
		Region 2	$K^{*(*)\delta(2)}(\theta)$	$K^{*(2)*(R)}(\theta)$				$K^{*(*)\sigma(2)}(\theta)$ or $K^{\epsilon(2)*(*)}(\theta+1)$	$K^{*(*)*(*)}(2)\ (\theta)$
Totals					$K^{*(*)*(*)}(\theta)$ (1)	$K^{*(*)*(*)}(\theta)$ (2)	$K^{*(*)*(*)}(\theta+1)$ (1)	$K^{*(*)*(*)}(\theta+1)$ (2)	

done for our British regions example. The diagonal terms represent the population stocks "transfered" between periods. The births and in-migrants are listed in the first two rows of the table, and the deaths and out-migrants in the first two columns.

In his 1971 monograph (Stone, 1971a) Stone introduces further terms in the central portion of the accounts matrix (e.g. Table III.11, P.34 in Stone 1971a) that represent a transfer between a state in one period to another state in the next period. However, strictly speaking, such transfers cannot occur in the open accounts framework and Stone has himself recognized the difficulties of using such accounts by basing his 1975 exposition (Stone, 1975) on closed demographic accounts, which we describe next.

The reason for the confusion is that the open accounts developed by Stone referred to the educational system where transfers between states occur at the end of one school and at the beginning of the next when pupils change classes, grades or schools. It is probably best to represent those transfers as occurring over a period even if they are concentrated in a short portion of that period.

2.4 Closed demographic accounts

So far, although we have considered the transitions into and out of many states the transitions between states have been neglected apart from those fundamental to any demographic system (birth, death and immigration/emigration transitions). Accounts that display multistate transitions fully are constructed as two-dimensional matrices together with their totals row and column. Table 5 shows such a set of multi-state demographic accounts for the British region example for the period mid-year 1970 to mid-year 1971.

The rows represent the initial states from which people start in a period. These initial states may be the state at the start of a period or the state into which persons are born at some time during a period. The columns represent the states in which people end up - either at the end of the period when still alive or at the time of their death before the end of the period. The accounts matrix links the two sets of states. Consider, for example, the rows and columns for the South. Some 22,687 thousands live there at mid-year 1970; of these 21,982 thousands survive and stay in the South, 76 thousands more move

Table 5. Closed accounts for aggregate regions, Britain, 1970-71 (1000s)

Initial State \ Final State		Survival at M.Y. 1971					Deaths, 1970-71					TOTALS
		N	M	S	C	A	N	M	S	C	A	
Existence at M.Y.1970	NORTH	14164.1	43.1	80.6	27.3	81.9	177.7	0.2	0.5	0.2	0.5	14576.0
	MIDLANDS	41.3	8428.1	69.5	15.9	51.5	0.3	92.7	0.4	0.1	0.3	8700.0
	SOUTH	75.8	77.2	21982.2	47.7	244.8	0.5	0.4	256.8	0.3	1.4	22687.0
	CELTIC	26.7	17.8	46.5	7683.9	59.1	0.2	0.1	0.3	95.9	0.4	7930.7
	ABROAD	60.1	41.6	240.1	37.5	0	0.4	0.2	1.4	0.2	0	381.4
Birth 1970-71	NORTH	238.2	0.4	0.7	0.2	0.7	1.5	0.0	0.0	0.0	0.0	241.5
	MIDLANDS	0.4	146.8	0.6	0.1	0.4	0.0	0.8	0.0	0.0	0.0	149.2
	SOUTH	0.6	0.6	344.7	0.4	1.9	0.0	0.0	2.0	0.0	0.0	350.1
	CELTIC	0.2	0.1	0.4	127.8	0.5	0.0	0.0	0.0	0.8	0.0	129.8
	ABROAD	0.5	0.4	1.8	0.4	0	0.0	0.0	0.0	0.0	0.0	3.0
TOTALS		14607.7	8756.1	22767.0	7941.0	440.7	180.5	94.5	261.3	97.5	2.6	55148.8

Source: Appendix 2.

m.y. = mid-year = June 30/July 1st

to the North, 77 thousands to the Midlands, 48 thousands to Scotland and Wales, and 245 thousands have emigrated abroad. Just under 257 thousands have died in the South and small numbers have died after migrating to the other sections. When the column for the South is examined we see that the region receives 81, 60, 47 and 240 thousands of migrants from the North, Midlands, the Celtic regions and Abroad, some 345 thousands born in the South and 0.7, 0.6, 0.4 and 1.8 thousands of infant migrants born in the other regions.

Table 6 shows for a two region system, the way in which the K notation defined earlier relates to the accounts. The variable K, representing persons or transitions, is classified by superscripts, the first of which represents the initial life-state, existence, ϵ, or birth, β, in a region, the identity of which is given in the brackets that follow immediately. The second superscript set gives the final life-state, survival, σ, or death, δ, in the region indicated in the brackets. In general, accounts contain four kinds of variables:-

$K^{\epsilon(i)\sigma(j)}$ - survivors, initially in existence in region i who survive in region j; when i=j they are stayers and when i≠j they are migrants;

$K^{\epsilon(i)\delta(j)}$ - non-survivors, initially in existence in region i who die in region j; when i=j they die in their initial region and when i≠j they migrate before dying;

$K^{\beta(i)\sigma(j)}$ - infant survivors, born in region i who survive in region j; when i=j they are stayers and when i≠j they are infant migrants;

$K^{\beta(i)\delta(j)}$ - infant non-survivors, born in region i who die in region j; when i=j they are stayers and when i≠j they migrate before dying in another region.

When asterisks replace superscripts this indicates that the superscript has been summed over. For example,

$$K^{\epsilon(i)*(*)} = \sum_j K^{\epsilon(i)\sigma(j)} + \sum_j K^{\epsilon(i)\delta(j)} \qquad (12)$$

Table 6. Closed accounts for a two region system of interest: symbolic representation

Initial States \ Fluvial States		Survival at m.y. 1971, Q			Deaths, 1970-71,			Totals
		Region 1	Region 2	Abroad, R	Region 1	Region 2	Abroad, R	
Existence at m.y. 1970,	Region 1	$K^{\epsilon}(1)\sigma(1)$	$K^{\epsilon}(1)\sigma(2)$	$K^{\epsilon}(1)\sigma(R)$	$K^{\epsilon}(1)\delta(1)$	$K^{\epsilon}(1)\delta(2)$	$K^{\epsilon}(1)\delta(R)$	$K^{\epsilon}(1)*(*)$
	Region 2	$K^{\epsilon}(2)\sigma(1)$	$K^{\epsilon}(2)\sigma(2)$	$K^{\epsilon}(2)\sigma(1)$	$K^{\epsilon}(2)\delta(2)$	$K^{\epsilon}(2)\delta(2)$	$K^{\epsilon}(2)\delta(R)$	$K^{\epsilon}(2)*(*)$
	Abroad, R	$K^{\epsilon}(R)\sigma(1)$	$K^{\epsilon}(R)\sigma(2)$	-	$K^{\epsilon}(R)\delta(1)$	$K^{\epsilon}(R)\delta(2)$	-	$K^{\epsilon}(R)*(*)$
Birth 1970-71,	Region 1	$K^{\beta}(1)\sigma(1)$	$K^{\beta}(1)\sigma(2)$	$K^{\beta}(1)\sigma(R)$	$K^{\beta}(1)\delta(1)$	$K^{\beta}(1)\delta(2)$	$K^{\beta}(1)\delta(R)$	$K^{\beta}(1)*(*)$
	Region 2	$K^{\beta}(2)\sigma(1)$	$K^{\beta}(2)\sigma(2)$	$K^{\beta}(2)\sigma(R)$	$K^{\beta}(2)\delta(1)$	$K^{\beta}(2)\delta(2)$	$K^{\beta}(2)\delta(R)$	$K^{\beta}(2)*(*)$
	Abroad, R	$K^{\beta}(R)\sigma(1)$	$K^{\beta}(R)\sigma(2)$	-	$K^{\beta}(R)\delta(1)$	$K^{\beta}(R)\delta(2)$	-	$K^{\beta}(R)*(*)$
Totals		$K^{*}(*)\sigma(1)$	$K^{*}(*)\sigma(2)$	$K^{*}(*)\sigma(R)$	$K^{*}(*)\delta(1)$	$K^{*}(*)\delta(2)$	$K^{*}(*)\delta(R)$	$K^{*}(*)*(*)$

The sum totals have particular interpretations in terms of items of available population data: the $K^{\varepsilon(i)*(*)}$ and $K^{*(*)\sigma(i)}$ terms are initial and final population stocks; the $K^{\beta(i)*(*)}$ and $K^{*(*)\delta(i)}$ terms are counts of births and deaths in the regions respectively.

The key feature of Tables 5 and 6 and of closed demographic accounts in general is the inclusion of a region that closes the system called "Abroad", "the Outside World", "the Rest of the World" or "Other countries". Without this region we could not interpret the accounts table sums in the useful way we have above. And we could not compute transition rates by dividing each element in the row of the accounts matrix by their row total that have the convenient property of summing to 1. The same point applies to the computation of admission rates through division of elements in a column by their column total.

However, it should be stressed that the closed demographic accounts framework deals with only the change from initial to final state and not with multiple changes of state in between. Thus, the closed accounts matrix does not contain the numbers of moves between states. Such movement accounts have been discussed by Rees (1977a), Illingworth (1976). and Jenkins (1976) and the differences between transitions and movements are discussed by Courgeau (1973) and in Ledent (1978a, 1978b, 1978c).

Ideally, one would like to match movements and transitions very precisely but this is only possible with good population registers. For most multistate projection, life table, and economic investigations (Stone, 1975, pp.45-46) accounts tables based on transitions are more appropriate and severe difficulties are encountered in estimating from register counts of movements and international migration counts the appropriate transition information. The only convenient solution for these "multiple transition" problems is to work with a time period short enough for the surplus of movements over transitions not to be large enough to matter.

A whole variety of different population investigations can be based on the information contained in a closed demographic accounts matrix or series of them. However, a description of such investigations is postponed to a later section of the paper. In the next section we describe a number of different examples of multistate demographic accounts using different state definitions.

3. Examples of multistate demographic accounts

3.1 Educational accounts

Stone (1971a, 1971b, 1972, 1975) has reviewed the application of accounting principles to the study of a variety of social and demographic systems. In particular, accounting and associated modelling techniques have been applied in the educational field. Table 7 shows a stocks and flows matrix taken from Stone (1972, p.64) in which the transitionsof pupils between various sectors of the educational hierarchy are charted. Fuller versions of such tables include a classification of pupils into single years of age and a more detailed description of the "21 - Other Employment" sector. The table reveals that relatively few of the secondary schoolboys in England and Wales proceed to further education compared with those that enter the labour market directly.

Transition proportions can be calculated for these transfers and this is done in Table 8 (Table 2, p.70 from Stone, 1972). The diagonal proportions are high indicating the movement of pupils within the various sectors, and these are reduced in larger versions of such accounts. Using the matrix of transition proportions given in Table 8, the fundamental matrix, $(\underline{I} - \underline{C})^{-1}$, can be computed. This is set out in Table 9 (Table 3, p.71 from Stone, 1972). This table yields an estimate of the numbers of years pupils spend in successive states, given that they start in those states and given that the matrix of transition proportions, $\underline{C}$, remains unaltered. In effect, $(\underline{I} - \underline{C})^{-1}$ is a discrete version of a multistate life expectancy matrix (Rees and Wilson, 1977, pp.259-270).

These three tables contain a wealth of information about the educational system of England and Wales in 1965-66, and the tendencies inherent in that system, should the transition proportions remain unchanged. The fundamental matrix (Stone, 1972, pp.75-77) provides life expectancies subdivided by time spent in different states. The average time spent in full time formal education for the whole male population is the sum of rows 2 through 18 in column 1, that is 13.08 years (with 10 being the legal minimum for most pupils in 1965-66). Calculated for many periods such a statistic would provide a valuable addition to a set of national social indicators. The life expectancy in subsequent educational states is clearly shown to be dependent on previous attainment. Thus boys attaining more than 1 A level can expect to spend 2.07 years at University (the entries in rows 16, 17 and 18 of column 9 added up) whereas those attaining no certificates can expect to spend only 0.10 of a year at university. Note that the

Table 7. The active sequence as a whole. England and Wales, male population (in thousands of males), 1965–66.

State in 1966 \ State in 1965	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
0 Outside world		10.9	1.1		0.5										0.1			0.1		0.9	0.3	89.8	178.5	282.3
1 Pre-school	435.6	1602.2																						2037.8
2 Nurs. and prim. schools	−4.0	411.8	2055.9																					2463.7
3 Spec. schools		5.8	0.8	35.7																				42.3
4 Sec. schools: 1st level	−1.5	2.5	324.6	0.1	896.1																			1222.8
5 Sec. schools: 2nd level					64.6	16.7																		81.3
6 Fin. schl. yr.: no cert.				5.1	187.3																			192.4
7 Fin. schl. yr.: O-levels					70.6																			70.6
8 Fin. schl. yr.: 1 A-lvl						8.8																		8.8
9 Fin. schl. yr.: > 1 A-lvl						42.9																		42.9
10 Furth. educ.: GCEO/ OND/ONC							2.5	3.3			5.8											5.9		17.3
11 Furth. educ.: GCEA/HND/HNC								2.7	1.0	1.3	5.0	5.7												16.7
12 Furth. educ.: ext 1st deg	0.1								0.1	3.2		0.3	4.9									0.5		9.1
13 Furth. educ.: ext 2nd deg	0.1													0.4				0.9						1.4
14 Furth. educ.: other courses							4.8	3.1	0.8	1.9					20.6							37.2		68.4
15 Teacher training coll								0.9	1.3	2.0		0.7				13.5		0.2		1.3	0.1	5.5		25.7
16 Univ. 1st deg.: med	0.1									1.8		0.2					7.7	0.3				0.4		10.5
17 Univ. 1st deg.: other										22.0	0.3	1.4	0.3					51.5				5.1		80.6
18 Univ. 2nd deg.	1.4																0.5	6.2	9.6			6.8		24.5
19 School teachers															0.3	6.9	0.1	0.4	2.0	134.3		0.5		144.5
20 Other teachers																0.7		0.2	1.4	1.3	54.2	0.1		57.9
21 Other employment	18.2						197.8	62.3	5.3	9.5	6.4	4.8	2.6	0.4	42.3	1.2	1.5	14.5	7.5	0.5	0.1	14414.5		14789.5
22 Home and retirement				0.1																1.5	0.6	162.4	2079.8	2244.4
Total	450.0	2033.2	2382.4	41.0	1219.1	68.4	205.1	72.2	8.7	41.7	17.5	14.1	8.0	0.8	63.3	22.3	9.8	74.3	20.5	139.8	55.3	14728.7	2258.4	

Source: Stone, 1972, Table 1, p.64.

Table 8.

The C-matrix of transition probabilities based on the fully adjusted version of Table 7, England and Wales, male population, 1965–66.

State in 1965 / State in 1966	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 Pre-school	0.802																					
2 Nurs. and prim. schools	0.186	0.868																				
3 Spec. schools	0.003		0.879																			
4 Sec. schools: 1st level	0.001	0.131	0.083	0.759																		
5 Sec. schools: 2nd level				0.035	0.370																	
6 Fin. schl. yr.: no cert.			0.118	0.153																		
7 Fin. schl. yr.: O-levels				0.053																		
8 Fin. schl. yr.: one A-level					0.109																	
9 Fin. schl. yr.: > 1 A-level					0.521																	
10 Furth. educ.: GCE/ONC/ONC						0.011	0.043			0.339												
11 Furth. educ.: GCE/A/ND/HNC							0.030	0.152	0.031	0.249	0.430											
12 Furth. educ.: ext. 1st deg.								0.013	0.072		0.023	0.467										
13 Furth. educ.: ext. 2nd deg.													0.370				0.009					
14 Furth. educ.: other sources						0.021	0.049	0.987	0.044					0.307							0.092	
15 Teacher training colleges							0.006	0.127	0.038		0.037				0.623		0.002		0.011	0.042		
16 Univ. 1st deg.: medicine									0.039		0.015					0.750	0.004					
17 Univ. 1st deg.: other									0.304	0.018	0.099	0.036					0.969					
18 Univ. 2nd deg.																0.050	0.008	0.444				
19 School teachers														0.003	0.269	0.007	0.004	0.068	0.939			
20 Other teachers															0.024		0.002	0.040	0.008	0.952		
21 Other employment						0.967	0.879	0.662	0.267	0.394	0.396	0.396	0.630	0.689	0.085	0.182	0.231	0.438	0.006	0.004	0.975	
22 Home and retirement																			0.032	0.027	0.013	0.980

Source: Stone, 1972, Table 2, P.70.

Table 9. The fundamental matrix, $(I-C)^{-1}$, based on Table 8 England and Wales, male population, 1965–66.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 Pre-school	5.05																					
2 Nurs. and prim. schools	7.16	7.55																				
3 Spec. schools	0.13	0.02	8.29																			
4 Sec. schools: 1st level	3.93	4.13	0.09	4.14																		
5 Sec. schools: 2nd level	0.22	0.23		0.23	1.59																	
6 Fin. schl. yr.: no cert.	0.61	0.63	0.99	0.63		1.00																
7 Fin. schl. yr.: O-levels	0.21	0.22		0.22			1.06															
8 Fin. schl. yr.: one A-level	0.02	0.02		0.02	0.17			1.00														
9 Fin. schl. yr.: > 1 A-level	0.11	0.12		0.12	0.83				1.00													
10 Furth. educ.: GCEO/ONDIONC	0.05	0.05	0.04	0.05	0.02	0.04	0.09	0.02	0.02	1.54	0.02	0.03	0.03	0.03	0.01	0.02	0.02	0.02			0.03	
11 Furth. educ.: GCEA/HNDIHNC	0.04	0.05	0.02	0.05	0.09	0.02	0.09	0.21	0.06	0.67	1.77	0.03	0.01	0.01		0.01	0.01	0.01			0.01	
12 Furth. educ.: ext. 1st deg.	0.02	0.03		0.03	0.15		0.01	0.04	0.17	1.04	0.10	2.32										
13 Furth. educ.: ext. 2nd deg.					0.02				0.02		0.01		1.59				0.04					
14 Furth. educ.: other courses	0.19	0.19	0.18	0.20	0.22	0.18	0.21	0.27	0.21	0.45	0.15	0.15	0.15	1.60	0.05	0.14	0.14	0.13	0.05	0.01	0.13	
15 Teacher training colleges	0.07	0.07	0.04	0.07	0.23	0.04	0.07	0.45	0.18	0.12	0.29	0.04	0.04	0.04	1.08	0.07	0.08	0.11	0.47	0.16	0.04	
16 Univ. 1st deg.: medicine	0.03	0.03	0.01	0.03	0.17	0.01	0.01	0.02	0.26	0.05	0.12	0.01	0.01	0.01		4.08	0.06				0.01	
17 Univ. 1st deg.: other	0.23	0.24	0.05	0.24	1.34	0.05	0.07	0.13	1.60	0.35	0.58	0.30	0.05	0.05	0.02	0.04	3.06	0.04	0.01		0.05	
18 Univ. 2nd deg.	0.06	0.07	0.04	0.07	0.23	0.04	0.04	0.04	0.27	0.08	0.32	0.07	0.04	0.04	0.01	0.45	0.46	1.03	0.01		0.04	
19 School teachers	0.43	0.44	0.25	0.45	1.48	0.25	0.40	2.06	1.27	0.46	1.29	0.31	0.24	0.32	13.62	1.31	1.11	2.57	18.96	0.71	0.24	
20 Other teachers	0.17	0.17	0.10	0.17	0.58	0.09	0.14	0.59	0.57	0.24	0.45	0.14	0.09	0.11	3.70	0.59	0.71	1.09	3.32	29.86	0.09	
21 Other employment	43.85	45.29	46.16	45.53	43.16	46.17	45.82	42.11	43.37	45.16	43.67	43.94	46.19	45.60	16.46	43.41	43.26	38.52	8.18	4.37	46.19	
22 Home and retirement	6.59	6.80	6.86	6.84	6.84	6.86	6.86	6.85	6.93	6.85	6.85	6.85	6.86	6.84	6.79	6.85	6.82	6.85	6.75	6.97	6.86	11.95

Source: Stone, 1972, Table 3, p.71.

latter figure is not zero. Of course, these are averages made up of some people spending 2,3,4,5 or 6 years at University and many spending no years.

Stone (1972, pp.75-77 and 1975, pp.42-50) discusses various ways in the accounts framework and derived models can be extended. The accounts themselves must be regarded as simply the starting steps in any investigation of a complex system. Simple projections forward of the tendencies observed in the system (as in Table 9) will not be satisfactory alone if the system exhibits supply constraints or bottlenecks. The monograph by Armitage, Smith and Alper (1969) considers in detail how such systems should be studied.

3.2 Socioeconomic group accounts

Other major systems described at length in Stone (1975) are those involving "social class, stratification and mobility" (Chapter XII) and "Earning activities, employment services and the inactive". Normally, social stratification and mobility studies are studied using elaborate social surveys and attention is focussed on inter-generational mobility, say between father's and son's occupation at a given age, over a rather indeterminate time period. Illingworth (1976) has attempted to construct matrices of the flows between socioeconomic groups over a specified period using census as well as survey data. Table 10 is an aggregated version of his Figure 9.2. The table is a set of closed demographic accounts with some age categories and some socioeconomic categories as the states.

The table provides a rich set of observations on the changing character of the England and Wales social system. Although the numbers of males economically active increase by 1.3% over the 5 year period, this overall increase conceals a decrease of 2.3% in manual workers and an increase of 9.5% in non-manual workers. Relatively little of the growth in non-manual employees (417,900) can be attributed (in this estimate) to social mobility (intragenerational) (net gain of 19,400). There is a minor surplus of recruits (from the 10-14 age group) over persons dying (18,800) with the main net inflow coming from the economically inactive (365,100). The recruits from this category are, of course, persons still in education and the people leaving the non-manual occupations to economic inactivity are mainly those retiring. Thus, a fairly rapid transformation of the social structure is being accomplished by differential entry and exit from the occupational system, predicted on a changing

Table 10. Socioeconomic group accounts for England and Wales and the Rest of the World 1961-66 (constructed under the high stay hypothesis), males

Initial State \ Final State		Survival at C.D. 1966						Died 1961-66 in		Totals
		England and Wales					Rest of World	EW	RW	
		0-9	10-14	Non-manual	Manual	Econ. Inactive				
BIRTHS 1961-66	England and Wales	2160.5					9.1	20.0	0.1	2189.8
	Rest of the World	24.7						0.1		24.8
Existence at C.D. 1961 — England and Wales	0-9	1798.2	1633.4				19.9	64.6	0.6	3516.8
	10-14			344.3	382.4	1069.4	26.0	84.4	0.8	1907.3
	Non-manual			3926.1	15.4	43.3	99.5	322.3	3.2	4409.8
	Manual			34.8	8891.0	108.4	248.9	806.6	7.9	10097.6
	Economically Inactive			428.4	475.7	1330.1	32.8	104.3	1.0	2372.4
RW	Immigrants	35.6	32.3	94.2	104.2	291.4		11.8		569.6
TOTALS		4019.0	1665.7	4927.7	9868.8	2842.6	435.7	1414.7	13.7	25088.1

Source: Aggregated and estimated from Illingworth (1976), Figure 9.2, p.294.

EW = England and Wales
RW = Rest of World
C.D.= Census date (circa April 23/24)

Components do not always add up to totals because of rounding off errors.

pattern of demand for different occupations. A more up-to-date version of these accounts would, however, reveal a slowing of the growth of white collar occupation and an increase in numbers in the economically inactive state.

3.3 Age and sex classified accounts

Age and sex have been variables of continuing interest to population researchers. What is surprising, perhaps, is that so much analysis has been undertaken without the benefit of the corresponding age-sex disaggregated closed demographic accounts. The reason is probably that an alternative framework - that of the life table - was adopted much earlier and that national demographers developed vital and census statistics that they felt supplied the data needs of the life table and associated projection models adequately.

Such a framework may be adequate where the area being studied constitutes a closed entity, little influenced by outflows to or inflows from outside. When a country like England and Wales is considered, or when a region with a country is studied, the assumption that the unit is a closed system is untenable. Table 11, containing a set of age-sex disaggregated demographic accounts for women in the inter-censal period 1961-66 in England and Wales, shows that out-migration removes 436,000 women from the population compared with mortality's 1,370,000, and that in-migration adds 582,000 compared with fertility's 2,136,000. Surviving in-migrants and out-migrants make up 45% of the sum of the vital flows. No attempt to "fudge" the closure problem by using net migrant concepts will do: the pattern of net migration by age in Table 10 shows extraordinary variation in the balance in successive age groups between positive and negative balance which no net migration model could hope to deal with.

The structure of Table 11 is a familiar one and is a transposed version of the matrix version of the cohort survival model proposed in the 1940s by Bernadelli (1941), Lewis (1942) and Leslie (1945). Survivors within England and Wales are entered in the diagonal one above the principal, indicating a complete transfer from one age group (of age interval 5 years) to the next, with the exception of the last, semi-closed age group where there is an entry in the principal diagonal. Although this arrangement of the accounts is often inconvenient when elements are being estimated, it is essential if the accounts are to be

Table 11. Age disaggregated demographic accounts for females in England and Wales, 1961–66

Initial State \ Final State	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65+	Out-migrant	Death	Totals
Age group at census date 1961, England and Wales																	
0–4	1805156														29788	10496	1846141
5–9		1640313													26843	3465	1670622
10–14	(82422)		1837614												63474	6218	1907306
15–19	(465030)			1550516											62637	8806	1621960
20–24	(638804)				1366905										59972	7507	1434385
25–29	(490534)					1377991									60175	7811	1445979
30–34	(264753)						1462204								28237	11177	1501637
35–39	(105414)							1566536							30192	19466	1616195
40–44	(18669)								1454232						9640	29950	1493822
45–49	(624)									1518398					10166	55239	1583802
50–54											1470427				10175	94800	1575403
55–59												1254790			6475	146580	1407846
60–64													913564		2998	179749	1096311
65+														1313145	5756	783526	2102426
In-migrts.	24443	55770	47093	44221	77620	91888	82747	44250	41290	19666	18052	16029	6339	8341	n.a.	4837	581986
Births	2111250														29305	280	2140835
Totals	2135693	1861027	1687405	1881835	1628137	1458793	1460739	1506454	1607827	1473898	1536450	1486456	1261129	2235047	435833	1369927	25026650

Source: Aggregated from Rees, Smith and King (1977), Tables

n.a. – not available (465030): indicates that these figures do not contribute to row and column sums

used in projection. If there are entries in the diagonal (as in Figure 13.33, pp.210-211 in Rees and Wilson, 1977 or Equation VII.20 in Stone, 1975, p.45) then use of the transition proportions in projection leads to erroneous results: people survive longer in an age group than that age group is long.

The birth entries are placed in the last row of the matrix although components of the births total, classified by age of mother at the start of the intercensal period, have been bracketed in the appropriate positions in the main body of the table. Surviving in-migrants from the rest of the U.K. and the rest of the world fall in the penultimate row of the accounts matrix and surviving out-migrants are placed in the penultimate column.

Appendix 3 shows the accounts of Table 11 in fully expanded form with both out-migrants and deaths classified by final as well as initial location and age group, and in-migrants are classified by initial as well as final location and age group. Births are classified by region of birth and mother's age group at the start of the period as well as region of survival, aged 0-4, at the end of the period. An alternative classification might be by mother's initial location at the start of the period since this makes a multistate application of Leslie's matrix model more straightforward, but such a classification is rarely available.

3.4 Multiregional, age-sex classified demographic accounts for a base period

The Table 11 and Appendix 3 accounts concern a national territory. However, this state should be broken down into its constituent regions if we are interested in the monitoring and projection of regional populations. In a report (Rees, 1977b; East Anglia Economic Planning Council, 1979) on the future population of East Anglia (Britain's fastest growing region) a set of multiregional age-sex disaggregated demographic accounts for a four region system consisting of East Anglia, the South East, the Rest of Britain and the Rest of the World were prepared for the intercensal period 1966-71. Presentation of such multistate accounts in the explicit form of Appendix 3 would occupy a vast and largely empty matrix so that instead the accounts are presented age cohort by age cohort in more compact tables in Appendix 1. In order to achieve compactness the death terms, which in Appendix 3 were classified by age

group at the start of the period and by age group at death, have been aggregated by adding together terms in each row of the full matrix.

These East Anglian accounts have been used as the base period data base in a multiregional projection of East Anglia's population (Rees, 1977b) and also in the development of multiregional life tables (Rees, 1979), although in the latter case the information concerning flows to and from the Rest of the World was ignored.

3.5 A time series of multiregional demographic accounts

Single or "one-off" sets of accounts, such as those described in the preceding examples, are rarely satisfactory since the migration and fertility behaviour and mortality experience of any population is continuously changing. What is needed instead is a time series of such accounts, relevant to the problem in hand, over the recent past. Such a time series is presented in Appendix 2 covering the years from mid-1970 to mid-1976 for the four sections of Great Britain for which we have already presented a series of different types of accounts. This series of accounts will be used in the next section to illustrate the procedures and problems involved in estimating accounts tables such as those illustrated in this section of the paper.

4. Estimation procedures for multistate demographic accounts

4.1 General principles

The main purpose of this section will not be to give an exhaustive account of estimation procedures for accounts building or of the main estimation models involved (see Stone, 1971a, 1975; Rees and Wilson, 1977) but rather to illustrate how the procedures can be applied in a particular case and how they must needs be adapted.

The main principles involved in accounts construction can be summarized in a series of instructions as follows:

(1) The specific purpose must be determined for which accounts are being constructed. This may involve the specification of the projection model for which the accounts will form the data base, though often the accounts framework will profoundly affect such a specification.

(2) A theoretical specification for the accounts must be designed in terms of "entities" to be accounted for and states between which the "entities" will transfer. This specification or disaggregation should not be too ambitious or problems of dimensionality will be encountered (c.f. Rogers, 1976). However, a state such as "the Outside World" as used in Stone's work (e.g. Table 7 in this paper) is probably too aggregated to be useful and should be broken down into separate birth, death and rest of the world categories. Often more disaggregation may be needed at the accounts estimation stage than at the later application stage.

(3) All tables of demographic and socioeconomic data relevant to the specification must be assembled and the degree of mismatch between the accounts design and available data supply determined. An attempt should then be made to separate out the resulting estimation problems into those in which reasonable data are available and those in which the data is unlikely to be forthcoming (usually involving parts of the accounts matrix such as the exist-die quadrant or the born-die quadrant).

(4) A series of estimation procedures must be designed to "massage" reasonable data into the form required for the accounts.

(5) An accounts based model must be designed to solve generally the latter kind of problem (see Rees and Wilson, 1977; Illingworth, 1976; Jenkins and Rees, 1977 for details of some of the alternatives).

(6). To the initial estimates of the accounts matrices must be applied to any additional constraints that may be available using the well-known "bi-proportional matrix" or "balancing factor" methods. When constraining row and column totals are used, they are often in conflict and judgment must be used in selecting the best set.

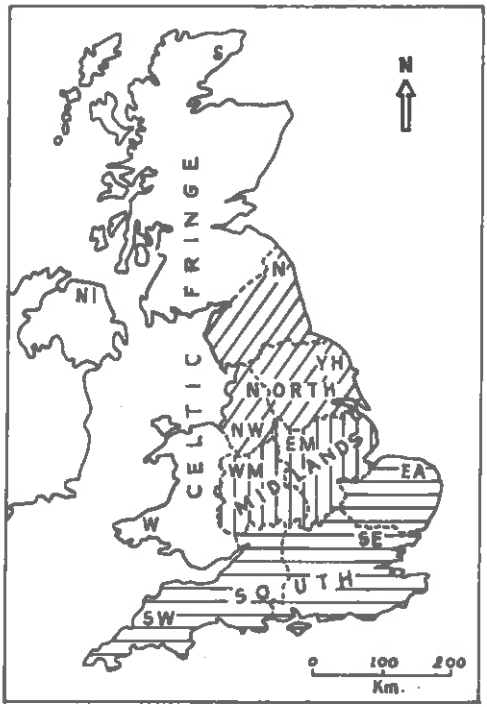
4.2 The British regions example: general outline

The accounts for sections of Britain set out in Appendix 2 are aggregates of those for British standard regions developed in a study of demographic change in Britain. The main purpose was to explore solutions to accounts building problems at the aggregate scale before applying them to age-sex disaggregated population accounts, to be used in population projection.

Closed demographic accounts for the all age and sex population of the standard regions of Great Britain (as specified earlier in Tables 5 and 6) were to be developed. The boundaries of these regions are set out in Figure 1 together with the definition of the aggregate regions or "sections" for which tables of statistics are presented in this paper. Northern Ireland was not included in the interaal set of regions because accurate data on migrants to Northern Ireland from the mainland regions were not available.

Three choices of single year period were available for accounts construction as set out in Figure 2: the calendar year between January 1st and December 31st; the "mid-year" from June 30th/July 1st in one year to June 30th/July 1st in the next; and the census year between census date at the end of April (April 25/26 in 1971) in one year and the same date in April in the next. Vital statistics (births, deaths, and international migrations) are most easily available for calendar years; official population estimates are prepared at mid-year and official population projections start from a mid-year base; and internal migration tables are available only for the year (or five years) prior to the census, taken in late April.

If good time series were available for all demographic components, choice of the appropriate accounting year would not matter as interpolation from one type of year to another could be easily accomplished. However, since the internal migration statistics were available only for one census year (1970-71) it was decided to build accounts initially for census years, and, when the best methods of accounts building had been determined,



STANDARD REGIONS

N = North YH = Yorkshire & Humberside NW = North West

EM = East Midlands WM = West Midlands

EA = East Anglia SE = South East SW = South West

W = Wales S = Scotland NI = Northern Ireland

"SECTIONS"

~ NORTH

~ MIDLANDS

~ SOUTH

~ CELTIC

Figure 1. The standard regions and sections of Great Britain

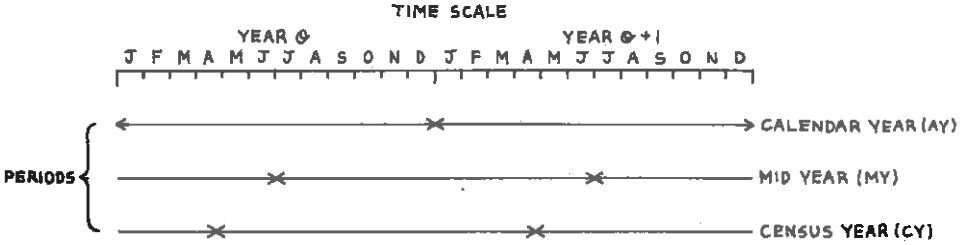


Figure 2. Alternative accounting years

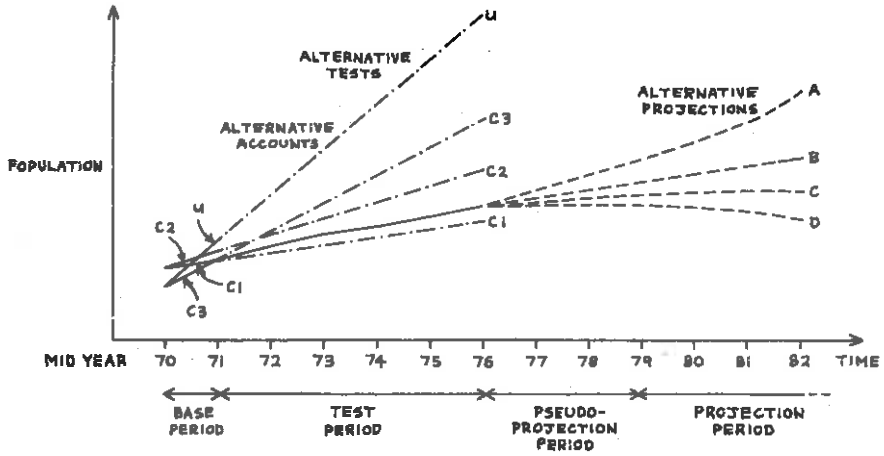


Figure 3. The structure of alternative accounts, tests and projections

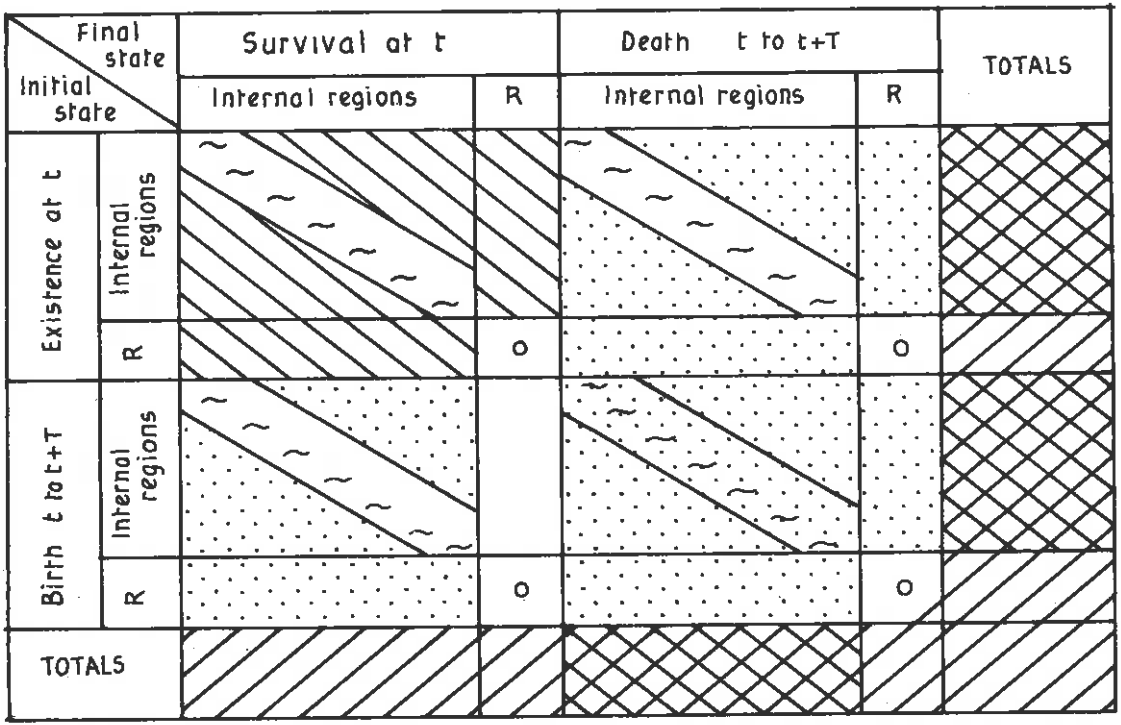
to use the transition matrix for 1970-71 census year as the basis of estimating mid-year accounts for 1970-76.

Figure 3 shows the strategy adopted. Four different ways are used to assemble accounts for the base period, 1970-71 (the year prior to the Census of 1971 in April of that year). Then the accounts are used as the base period data in a series of projections through to 1976, (the latest year for which estimates were available at time of computation in early 1978) either with rates fixed at their 1970-71 level or with birth and death rates and external migrant vectors allowed to take on their estimated values for the intervening years 1971-76. In both cases the internal migration rates remain fixed at their 1970-71 values. The later are, however, rather sensitive to the method of accounts building adopted, and a comparison of "projected" and estimate populations reveals which method gives the best fit accounts. This method can then be adopted to construct accounts for the individual years 1971-72, 1972-73, 1973-74, 1974-75 and 1975-76 set out in Appendix 2.

In Figure 4 are set out the items of an accounts table classified in terms of their origin. Type 1 terms are input as data to an accounts based model; type 2 terms are estimated by simple equations in the accounts based model and type 3 terms are computed as residuals using the row and column equations. The exact scheme of equations differs according to whether aggregate, semi-aggregate (the existence and birth parts of the aggregate accounts are treated separately) or age-disaggregated accounts are being constructed. Aggregate model equations are set out in Rees and Wilson (1977, Part 2), in Jenkins and Rees (1977), and in Illingworth (1976); the semi-aggregate model is described in Jenkins and Rees (1977); the age-disaggregated model is set out in Rees and Wilson (1977, Part 3) and in Rees, Smith and King (1977) and in simpler form in Rees (1978).

Type 4 elements in the accounts table (Figure 4) are the row and column totals which may be used as constraints to which the initial estimate of the accounts matrix is adjusted (as spelled out in Rees, 1978b).

The steps undertaken in the development of the time series of multi-state demographic accounts are set out in Figure 5. Each step is described briefly and the outputs displayed in the sections of the paper that follow.



KEY

Type 1
Terms input as data

Type 2
Terms estimated in accounts based model by minor flow eqs

Type 3
Terms estimated using row x column accounting equations

Type 4
Terms that may be used as constraints

R = Rest of World

Figure 4. The terms in an accounts table classified by method of estimate

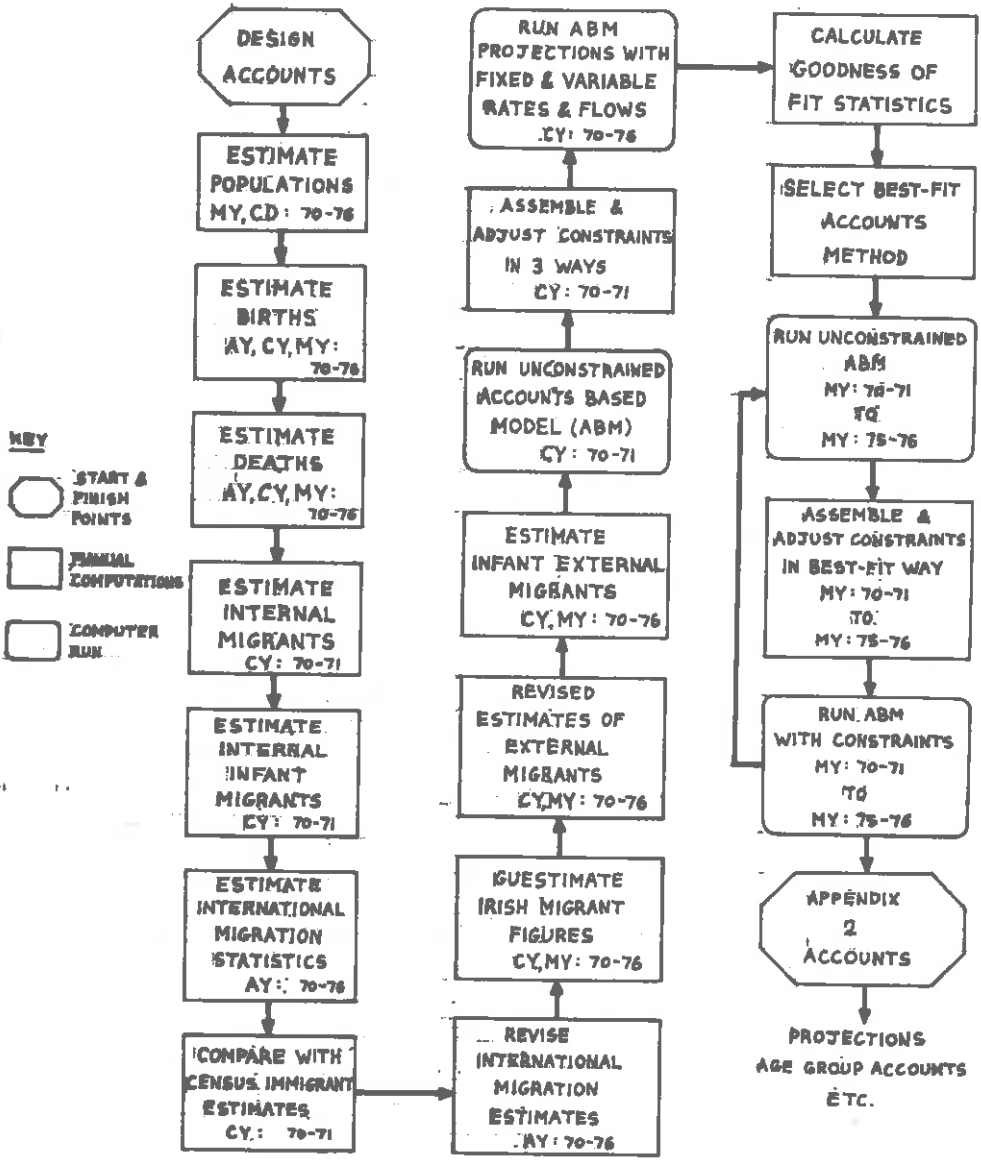


Figure 5. Steps in the development of a time series of multistate demographic accounts (regions of G.B. 1970-76)

4.3 Assembly of tables of demographic statistics and estimation of data required as input to the accounts based model

The step of assembling tables of demographic statistics relevant to the task at hand should be a relatively simple operation but rarely is.

Table 12 contains the first such set of statistics, for population. Mid-year population estimates were used as the Office of Population Censuses and Surveys (hereafter referred to as O.P.C.S.) had prepared such a series for the "new" regions (post-April 1, 1974 definitions). The most reliable estimates are those for 1971 (the year of the census) and the accuracy (unknown) of the estimates decays away from this date. These estimates are for the "home" population definition, the most appropriate for accounts building. Census date (April 25/26) estimates were interpolated between mid-years using an exponential interpolation function (Table 12.2).

Birth estimates (Table 13) were taken from the O.P.C.S. publication Population Trends, principally because it provides estimates converted to a new region basis for years prior to local government reorganization. Annual births (for the calendar year) had to be converted to census year and mid-year figures and this was done using simple apportionment fractions:

$$B^i(\theta,\theta+1) = F_2 \times B^i(\theta) + F_1{}^i \times B(\theta+1) \qquad (13)$$

where B^i are the live births in region i and θ and $\theta+1$ are the labels attached to successive calendar years which are, in pairs, used to identify single census or mid-years. F_1 refers to the fraction of births falling in the first part of the year and F_2 that falling in the second part of the year. These are computed from national quarterly or monthly births figures.

A similar equation is used to produce the corresponding estimates of deaths in the regions (Table 14).

Information on migration between British regions is, unfortunately, collected only at the periodic censuses, so that only one table, for the year prior to census date 1971, can be presented (Table 15). However, this table does give the right type of migration statistics: those for persons (migrants in Courgeau, 1973's typology and transitions in Ledent,

Table 12. Population estimates (home definition) for sections of Great Britain, 1970-76

12.1 Mid-year estimates (1000s)

Section	1969	1970	1971	1972	1973	1974	1975	1976
North	14563	14576	14607.7	14627.2	14632.3	14619.0	14599.2	14568.5
Midlands	8653	8700	8756.1	8815.2	8859.2	8894.1	8903.9	8898.0
South	22613	22687	22767.0	22861.3	22933.8	22930.9	22932.0	22950.6
Celtic Fringe	7919.5	7930.7	7941.0	7945.0	7961.0	7973.8	7970.5	7971.9
G. Britain	53748.5	53893.7	54071.8	54248.7	54386.3	54417.8	54405.6	54389.5

Sources: Aggregated from OPCS (1975), Table 8, p 40 and OPCS (1977a), Table 17, p 43

12.2 Census date estimates (1000s)

Section	1970	1971	1972	1973	1974	1975	1976
North	14573.6	14602.0	14623.7	14631.4	14621.4	14602.8	14574.0
Midlands	8691.5	8745.9	8804.5	8851.2	8887.8	8902.1	8899.5
South	22673.6	22752.5	22844.2	22920.6	22931.4	22931.8	22947.2
Celtic Fringe	7928.6	7939.1	7944.3	7958.1	7971.5	7971.1	7971.6
G. Britain	53867.3	54039.5	54216.7	54361.3	54412.1	54407.8	55492.3

Source: Interpolated from Table 12.1 above using an expon ential interpolation function

Table 13 Birth estimates for sections of Great Britain, 1970-76

13.1 Calendar year births (1000s)

Section	1970	1971	1972	1973	1974	1975	1976
North	242.5	240.7	219.9	201.4	190.4	180.1	174.4
Midlands	149.2	149.2	137.2	128.3	120.1	112.6	109.0
South	350.2	350.2	327.9	308.3	292.5	276.3	267.5
Celtic Fringe	129.8	129.8	118.6	112.0	106.3	101.9	101.7
Great Britain	871.7	869.9	804.0	750.3	710.0	671.4	652.6

Source: Aggregated from O.P.C.S. (1977a), Table 22, p.48.

13.2 Census year births (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
North	241.9	233.9	213.8	197.8	187.0	178.2
Midlands	149.2	145.3	134.3	125.6	117.6	111.4
South	350.2	342.9	321.5	303.1	287.2	273.4
Celtic Fringe	129.8	126.1	116.4	110.1	104.9	101.8
Great Britain	871.1	848.2	786.0	736.6	696.7	664.9

Source: Computed from Table 13.1. $F_1 = .327272$ $F_2 = .672728$

13.3 Mid-year births (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
North	241.5	230.0	210.4	195.7	185.1	177.1
Midlands	149.2	143.0	132.6	124.1	116.2	110.7
South	350.1	338.7	317.7	300.1	284.1	271.8
Celtic Fringe	129.8	124.0	115.2	109.1	104.0	101.8
Great Britain	870.6	835.7	775.9	728.9	689.5	661.4

Source: Computed from Table 13.1. $F_1 = .513029$ $F_2 = .486791$

Table 14. Death estimates for sections of Great Britain, 1970-76

14.1 Calendar year deaths (1000s)

Section	1970	1971	1972	1973	1974	1975	1976
North	182.4	178.7	187.2	184.2	183.1	180.7	180.2
Midlands	95.4	93.6	98.6	97.9	98.3	97.7	101.7
South	262.5	260.2	268.5	267.8	266.5	267.0	282.6
Celtic Fringe	98.6	96.4	101.0	100.3	100.3	98.6	101.2
G. Britain	638.9	628.9	656.9	652.0	650.0	645.9	665.6

Source: Aggregated from O.P.C.S. (1977), Table 31, p.62.

14.2 Census year deaths (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
North	181.1	181.7	186.2	183.8	182.3	180.5
Midlands	94.8	95.3	98.4	98.0	98.1	99.1
South	261.7	263.1	268.3	267.3	266.7	272.4
Celtic Fringe	97.8	98.0	100.8	100.3	99.7	99.5
G. Britain	635.4	638.1	653.5	649.5	646.7	651.5

Source: Computed from Table 14.1. $F_1 = .347765$ $F_2 = .652235$

14.3 Mid year deaths (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
North	180.5	183.1	185.6	183.6	181.8	180.4
Midlands	94.5	96.2	98.2	98.1	98.0	99.8
South	261.3	264.5	268.1	267.1	266.8	275.1
Celtic Fringe	97.4	98.8	100.6	100.3	99.4	100.0
G. Britain	633.7	642.7	652.6	649.2	646.0	655.3

Source: Computed from Table 14.1 $F_1 = .522958$ $F_2 = .477042$

Table 15. Internal migrants for sections of Great Britain 1970-71 (10% sample figures multiplied by 10)

15.1 Exist-survive migrants

Origin \ Destination	Section of residence, April 25/26, 1971				Totals
	North	Midlands	South	Celtic Fringe	
North	-	44300	90800	27260	162360
Midlands	40010	-	76030	15520	131560
South	67030	70330	-	42020	179380
Celtic Fringe	26830	18230	52630	-	97690
Totals	133870	132860	219460	84800	570990

Source: Aggregated from unpublished table DT 4312 OPCS (1976), subsequently published as OPCS (1978a)

15.2 Infant migrants

Place of birth \ Destination	Section of residence				Totals
	North	Midlands	South	Celtic Fringe	
North	-	369	754	189	1312
Midlands	342	-	652	134	1128
South	517	544	-	324	1385
Celtic Fringe	304	148	430	-	882
Totals	1163	1061	1836	647	4707

Source: Estimated using data in Table 15.1 and Table 13

1978c's typology) rather than for moves (migrations or movement). Inclusion of move type data in an accounts table (or derived set of projection or multiregional life tables) results in an overestimation of the amount of initial state-final state change occurring in the system.

Infant migrants (Table 15.2) should be readily available from the same source as the migrant data but are not. So the Table 15.2 data are estimated using the following equations

$$K^{\beta(i)\sigma(j)} = \tfrac{1}{2} h^{\epsilon(i)\sigma(j)} K^{\beta(i)*(*)} \qquad (14)$$

$$h^{\epsilon(i)\sigma(j)} = K^{\epsilon(i)\sigma(j)} / K^{\epsilon(i)*(*)} \qquad (15)$$

where $h^{\epsilon(i)\sigma(j)}$ is the transition rate from region i to region j by persons in existence at the start of the accounting period and alive at the end. The assumption is made that the infants migrate at the rate of the rest of the population but have only half of the period, on average, in which to accomplish the migration.

The transition rates matrix of 1970-71 is used to estimate the internal migrant behaviour of the population in the period 1971-76. Estimates of this behaviour are prepared by O.P.C.S. from National Health Service Register transfers as part of the process of producing net migration estimates as input to the population estimates themselves (c.f. Equation (2)), but they are not readily available. Good annual estimates of inter-regional migration could be very simply generated from the General Household Survey (O.P.C.S., 1973, Chapter 5) but O.P.C.S. is reluctant to disaggregate its sample spatially. However, a glance forward at the internal migrant figures in the Appendix 2 accounts shows that the methods adopted here result in estimates rather more invariant than is probably the case.

International migration statistics are available for calendar years between 1970 and 1976 but the statistics (Table 16) pose a number of difficult estimation problems.

The Table 16.1 data are based on the I.P.S. or International Passenger Survey (O.P.C.S., 1978b, pp.10-13), a 1-2% sample survey of passengers arriving at or leaving U.K. airports and seaports. No attempt is made

Table 16. International migration statistics, G.B., 1970-76

16.1 Original data (1000s)

Section	1970	1971	1972	1973	1974	1975	1976
IMMIGRATION	← OLD REGIONS →				← NEW REGIONS →		
Celtic Fringe	17.2	15.2	16.8	16.1	15.8	-	-
England	207.0	183.0	204.2	178.6	166.3	-	-
North	-	32.8	31.7	30.2	30.4	-	-
Midlands	-	20.0	24.6	23.0	17.6	-	-
South	-	130.1	147.9	125.3	118.4	-	-
G.B. Total	224.2	198.2	221.0	194.7	182.1	-	-
U.K. Total	225.6	199.7	221.9	195.7	183.8	197.2	179.8
EMIGRATION							
Celtic Fringe	31.9	27.3	27.4	26.1	32.2	-	-
England	252.7	209.0	199.4	213.7	231.8	-	-
North	-	51.4	44.2	45.9	53.6	-	-
Midlands	-	26.5	20.5	24.1	27.3	-	-
South	-	131.1	134.7	143.8	150.8	-	-
G.B. Total	284.6	236.3	226.9	239.9	264.1	-	-
U.K. Total	290.7	240.0	233.2	245.8	269.0	238.3	210.4

Source: 1970 - O.P.C.S. (1977b), Table 2.7; 1971-74 - O.P.C.S. (1977b), Tables 2.7 and 2.15; 1975-76 - O.P.C.S. (1977a), Table 26.

16.2 Converted data (1000s)

Section	1970	1971	1972	1973	1974	1975	1976
IMMIGRATION	← NEW REGIONS →						
North	36.5	32.3	31.2	29.7	30.4	32.7	29.7
Midlands	23.3	20.5	25.1	23.5	17.6	18.9	17.2
South	147.2	130.1	147.3	125.3	118.4	127.0	115.8
Celtic Fringe	17.2	15.2	16.8	16.1	15.8	17.0	15.5
G.B. Total	224.2	198.2	221.0	194.7	182.1	195.5	178.2
EMIGRATION							
North	61.2	50.6	43.5	45.2	53.6	47.3	41.9
Midlands	33.0	27.3	21.2	24.8	27.3	24.2	21.4
South	158.5	131.1	134.7	143.8	150.8	133.6	117.9
Celtic Fringe	31.9	27.3	27.4	26.1	32.4	28.7	25.3
G.B. Total	284.6	236.3	226.8	239.9	264.1	234.0	206.6

Source: Estimated from data in Table 16.1.

to survey traffic (and migrants) between the U.K. and the Irish Republic, some ports are omitted from the survey and no account is taken of military traffic. Migrants in the survey are respondents indicating an intention to stay at least one year at their destination.

Disaggregation by region of origin or destination was introduced only in 1971, and was unavailable at time of compilation for 1975 and 1976. To fill out the table and to produce Table 16.2 the regional proportions of 1971 were used to breakdown the 1970 statistics, and the proportions for 1974 were used to break down the 1975 and 1976 proportions.

It was felt important to check the accuracy of the I.P.S. statistics against equivalent statistics for 1970-71 available in the Census 1971 migration tables. This is done in Table 17 for the immigration stream "Outside the British Isles" to "U.K. regions" (emigration figures are, of course, unavailable at the census).

Column (5) contains the I.P.S. estimates adjusted to the 1970-71 census year using the equivalent of Equation (13) (the F_1 and F_2 proportions are given in Table 20). The Census figures are given in Column (3) of Table 17 but these are inflated marginally to include other kinds of migrants (non-survivors, infants and non-surviving infants) to make the match with the I.P.S. statistics more exact. A comparison of Columns (4) and (5) is disturbing. Column (6) of the table reveals that the Census figures are 50 to 100% larger than the I.P.S. estimates. Clearly, one has either to believe the Census figure or the I.P.S. estimate, and in terms of relative reliability it must be the Census that is chosen.

Therefore, revised estimates of immigrants to and emigrants from G.B. regions (to and from the World outside the British Isles) were prepared (Table 18) by multiplying the Table 16.2 figures by the ratios given in Column (8) of Table 17 of the Column (3) census statistics to the I.P.S. estimates (Column (5)). To these estimates must be added estimates of migrants to and from Northern Ireland, and to and from the Irish Republic, Isle of Man and Channel Islands. The immigrant figures for 1970-71 Census year derive from the census migration tables. To the total immigration from Northern Ireland for Great Britain is added the net migration estimate for Northern Ireland available in O.P.C.S. (1977, Tables 3 and 4), and the resulting emigrant total distributed among the regions in the same proportion as immigrants. The net migration estimate for successive years is related to immigrant and

Table 17. Comparison of IPS and Census immigration estimates, 1970-71 (1000s)

Section	CENSUS, 1970-71 Abroad (A) (1)	Elsewhere in British Isles (EBI) (2)	Outside British Isles (A-EBI) (3)	CENSUS Plus Est.s of other accounts terms (A-EBI) (4)	IPS Immigration est. (5)	RATIO (4/5) x100 (6)	RATIO (3/4) (7)	COMBINED RATIO (3/5) (8)
North	59.6	8.0	51.6	52.4	35.5	148	.985	1.45
Midlands	41.7	4.6	37.1	37.8	22.6	167	.981	1.64
South	246.9	21.0	225.9	228.9	143.2	160	.987	1.58
Celtic Fringe	37.0	3.2	33.8	34.5	16.7	207	.980	2.02
G.B. Total	385.2	36.8	348.4	353.5	218.1	162	.986	1.60

Sources: Columns (1) to (3) - Aggregated from unpublished Table DT4312, O.P.C.S. (1976) subsequently published as O.P.C.S. (1978a).
Column (4) - Estimated using factors from accounts for 1970-71 given in Rees (1976).
Column (5) - Estimated from 1970 and 1971 column of Table 16.2, Immigration section.

Table 18. Revised estimates of immigrants and emigrants, G.B., 1970-76 (1000s)

Section	1970	1971	1972	1973	1974	1975	1976
IMMIGRANTS							
North	53.1	46.9	44.7	44.1	44.9	48.3	44.0
Midlands	38.2	33.7	42.4	37.9	29.1	31.2	28.4
South	232.2	205.2	233.7	197.8	190.9	204.8	186.7
Celtic Fringe	34.4	31.8	35.4	33.3	32.2	34.6	31.5
G.B. Total	357.9	317.6	356.2	313.1	297.1	318.9	290.6
EMIGRGRANTS							
North	88.3	73.0	64.5	65.2	79.2	69.8	61.9
Midlands	55.3	45.8	35.1	42.2	45.9	40.7	35.9
South	257.5	213.0	218.0	239.4	249.3	220.9	195.0
Celtic Fringe	64.4	55.2	56.3	53.0	66.1	58.6	51.7
G.B. Total	465.5	387.0	373.9	399.8	440.5	390.0	344.5

Source: Estimated through application of Table 17, Column (8) ratios to Table 16.2 values.

emigrant totals in the same ratio as in 1970-71, and the totals allocated to regions in the proportions observed in 1970-71. For the other parts of the British Isles all that was available was an estimate of migration between the Irish Republic and the U.K. (Central Statistical Office, 1970, Table 18): the ratio of emigrants to immigrants was applied to the Census 1971 immigrants figure for the Irish Republic and the Isle of Man and Channel Islands.

The resulting statistics are no more than "guestimates": the figures for census years and mid-years have been assumed approximately equal, and the Irish Republic flow is assumed to continue at its guessed 1970-71 level, in the absence of any other information.

The grand totals of migrant flows to and from the sections of Great Britain are presented in Table 20 in census year form and mid-year form. Table 20 is simply a product of converting the Table 18 figures to census years and mid-years and adding the figures in Table 19. Note the high degree of concentration of international migrants in the second half of the year (particularly the July-September quarter).

Finally, estimates (given in Table 21) of the numbers of surviving infant external migrants are made using Equations (14) and (15) directly for emigrant flows, and in modified form for immigrant flows

$$K^{\beta(R)\sigma(j)} = \tfrac{1}{2} b^{j} K^{\epsilon(R)\sigma(j)} \qquad (16)$$

where b^{j} is the birth rate of region j.

We have now travelled down the first column of steps in Figure 5 and half way up the second column. Some steps are rather more robust than others, and the creaking of some is positively deafening. However, none could be omitted without serious bias to the resulting accounts. The numbers in the accounts to be described have a large margin of error attached to them, and have therefore been presented in all tables to the nearest hundred, though the level of accuracy is probably no more than to the nearest thousand. However, it would be relatively easy (and cheap) for official statistical bodies to improve on the accuracy of the accounts presented in this paper, should they adopt the framework.

Table 19. Estimates of migrants to and from elsewhere in the British Isles, G.B. sections, 1970-76 (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
IMMIGRANTS FROM NORTHERN IRELAND						
North	4.0	6.4	5.8	5.8	4.7	4.7
Midlands	1.9	3.0	2.8	2.8	2.2	2.2
South	7.3	11.8	13.5	13.5	8.6	8.6
Celtic Fringe	1.8	2.9	2.6	2.6	2.1	2.1
G.B. Total	14.9	24.1	22.0	22.0	17.6	17.6
EMIGRANTS TO NORTHERN IRELAND						
North	2.9	4.7	4.3	4.3	3.4	3.4
Midlands	1.4	2.2	2.0	2.0	1.6	1.6
South	5.3	8.6	9.9	9.9	6.3	6.3
Celtic Fringe	1.3	2.1	1.9	1.9	1.5	1.5
G.B. Total	10.9	17.6	16.1	16.1	12.9	12.9
IMMIGRANTS FROM THE IRISH REPUBLIC, ISLE OF MAN AND CHANNEL ISLANDS						
North	4.1	4.1	4.1	4.1	4.1	4.1
Midlands	2.7	2.7	2.7	2.7	2.7	2.7
South	13.7	13.7	13.7	13.7	13.7	13.7
Celtic Fringe	1.5	1.5	1.5	1.5	1.5	1.5
G.B. Total	22.0	22.0	22.0	22.0	22.0	22.0
EMIGRANTS TO THE IRISH REPUBLIC, ISLE OF MAN AND CHANNEL ISLANDS						
North	1.8	1.8	1.8	1.8	1.8	1.8
Midlands	1.2	1.2	1.2	1.2	1.2	1.2
South	6.2	6.2	6.2	6.2	6.2	6.2
Celtic Fringe	0.7	0.7	0.7	0.7	0.7	0.7
G.B. Total	10.0	10.0	10.0	10.0	10.0	10.0

Sources: Immigrants 1970-1 - Aggregated from figures in unpublished Table DT 4312 (O.P.C.S., 1976), later published in O.P.C.S. (1978a). Immigrants 1971-6, Emigrants - Method of estimation is described in the text. The net migration estimates used derive from O.P.C.S. (1977a). The figures are assumed to apply to both census and mid years.

Table 20. Revised estimates of immigrants and emigrants, G.B., 1970-76, census years and mid years

20.1 Census year estimates (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
IMMIGRANTS						
North	59.6	56.9	54.5	54.2	54.5	56.0
Midlands	41.7	41.5	46.8	41.3	34.5	35.5
South	246.9	237.4	249.7	220.7	216.5	222.9
Celtic Fringe	37.0	37.0	39.0	37.1	36.4	37.4
G.B. Total	385.2	372.8	390.0	353.3	341.9	351.9
EMIGRANTS						
North	88.8	77.2	70.8	75.2	81.9	72.9
Midlands	55.3	46.3	40.3	46.5	47.3	42.2
South	256.8	229.2	238.0	256.2	254.0	226.3
Celtic Fringe	63.8	58.3	58.0	59.2	66.3	58.9
G.B. Total	464.7	411.0	407.0	437.1	449.5	400.4

Source: Estimated from Tables 18 and 19. F_1 = .235264 F_2 = .764736

20.2 Mid year estimates (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
IMMIGRANTS						
North	58.7	56.5	54.4	48.0	55.0	55.4
Midlands	41.0	42.8	46.2	37.8	34.8	35.1
South	242.9	241.7	244.4	193.2	218.6	220.2
Celtic Fringe	36.6	37.5	38.7	32.5	36.7	37.0
G.B. Total	379.2	378.5	383.6	311.5	345.1	347.7
EMIGRANTS						
North	86.4	75.9	70.9	77.4	80.4	71.7
Midlands	53.8	44.6	41.4	47.1	46.5	41.5
South	249.8	230.0	241.3	257.8	249.6	222.2
Celtic Fringe	62.4	58.5	57.5	61.3	65.1	57.8
G.B. Total	452.4	408.9	411.1	443.5	441.6	393.3

Source: Estimated from Tables 18 and 19. F_1 = .383681 F_2 = .616319

Table 21. Estimates of infant immigrants and emigrants, G.B., 1970-76, census years and mid years

21.1 Census year estimates (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
INFANT IMMIGRANTS						
North	0.5	0.5	0.4	0.4	0.3	0.3
Midlands	0.4	0.3	0.4	0.3	0.2	0.2
South	1.9	1.8	1.8	1.5	1.4	1.3
Celtic Fringe	0.3	0.3	0.3	0.3	0.2	0.2
G.B. Total	3.1	2.9	2.8	2.4	2.2	2.2
INFANT EMIGRANTS						
North	0.7	0.6	0.5	0.5	0.5	0.4
Midlands	0.5	0.4	0.3	0.3	0.3	0.3
South	2.0	1.7	1.7	1.7	1.6	1.4
Celtic Fringe	0.5	0.5	0.4	0.4	0.4	0.4
G.B. Total	3.7	3.2	2.9	2.9	2.8	2.4

21.2 Mid year estimates (1000s)

Section	1970-1	1971-2	1972-3	1973-4	1974-5	1975-6
INFANT IMMIGRANTS						
North	0.5	0.4	0.4	0.3	0.3	0.3
Midlands	0.4	0.3	0.3	0.3	0.2	0.2
South	1.8	1.8	1.7	1.3	1.4	1.3
Celtic Fringe	0.3	0.3	0.3	0.2	0.2	0.2
G.B. Total	3.0	2.9	2.7	2.1	2.1	2.0
INFANT EMIGRANTS						
North	0.7	0.6	0.5	0.5	0.5	0.4
Midlands	0.5	0.4	0.3	0.3	0.3	0.3
South	1.9	1.7	1.7	1.7	1.5	1.3
Celtic Fringe	0.5	0.5	0.4	0.4	0.4	0.4
G.B. Total	3.6	3.1	2.9	2.9	2.7	2.4

Source: Estimated using data in Tables 13 and 20.

4.4 Application of the accounts based model in the base period and subsequent tests

Once the component demographic data have been assembled the figures for census year 1970-71 are selected and input to an unconstrained version of the accounts based model (Figure 5). This is done in order to yield estimates of the totals for immigrants, infant immigrants, surviving emigrants and non-surviving emigrants to use as constraints along with the population, births, and deaths totals.

The next step is then to examine the marginal totals and to check their consistency, that is, whether the sum of row marginal totals adds up to the sum of column marginal totals. Unless this condition is satisfied the adjustment of the initial estimate of the accounts matrix to the full set of marginal constraints will not be possible.

Table 22 shows that, when these initial constraints (Columns (1) and (2) in the table) are added up, they rarely tally. There is a difference of 17,197 between the row total and column total sums. It is then necessary to adjust some or all of the constraint figures in order to achieve a proper tally. There are clearly a very large number of ways in which this could be done, and choice of which numbers to adjust will depend on assessment of the reliability of each constraint statistic.

Three different adjustments were used in the case of these British region accounts.

(1) Firstly, the difference between the row total and column total sums was assigned entirely (and proportionately) to the two emigrant terms. Our discussion of prior data estimation steps has revealed these to be the least reliable demographic statistics. This is the adjustment shown in Columns (3) and (4) in Table 22. We will call this method the emigrant adjustment method and label it C1.

(2) A second method is to distribute the difference between the initial row totals sum and column totals sum amongst the initial populations of the sections proportionately to their size. The argument for this approach is that the 1970 population estimate is likely to be substantially in error as it is nine years after the previous full Census (1961) and errors of estimation will be at their maximum. We will call this the initial population adjustment method and label it C2.

Table 22. The constraints adjustment procedure illustrated for 1970-1

Sections	Initial constraints		Adjusted constraints	
	Row Totals (1)	Column Totals (2)	Row Totals (3)	Column Totals (4)
	Initial populations	Final populations	Initial populations	Final populations
North	14573648	14601962	14573648	14601962
Midlands	8691483	8745928	8691483	8745928
South	22673582	22752492	22673582	22752492
Celtic Fringe	7928566	7939136	7928566	7939136
	Immigrants	Surviving emigrants	Immigrants	Surviving emigrants
Abroad	387442	468422	387442	451325
	Births	Deaths	Births	Deaths
North	241911	181114	241911	181114
Midlands	149200	94774	149200	94774
South	350200	261701	350200	261701
Celtic Fringe	129799	97904	129799	97904
	Infant immigrants	Non-surviving emigrants	Infant immigrants	Non-surviving emigrants
Abroad	3071	2736	3071	2636
Totals	55128902	55146099	55128902	55128902

Source: University of Leeds ICL 1906A file :GEOPHRG.AUCP7071RES containing the unconstrained accounts based on more detailed versions of the relevant statistics from Tables 12, 13, 14, 15, 20 and 21.

(3) A third method is to work out the differences between the final populations produced by the unconstrained accounts and the census based 1971 populations, and to add these differences to the initial population. This we will call the "backcast" method, and label it C3.

Three slightly different sets of accounts result from using these different constraint adjustment procedures, all of which will differ from the unconstrained set of accounts, which we label U.

The accounts based model is then used in projection mode in one of two ways. In the fixed rate projections the birth rates, death rates, internal migration rates, internal infant migration rates, and external migrant and infant migrant vectors associated with the 1970-71 Census are used to project the regional populations forward to 1976 (census date). In the variable rate projections the birth rates, death rates and external migrant and infant migrant vectors for the intervening years (derived from Tables equivalent to those presented earlier) are used, only the internal migration and infant migration rates remain fixed. Thus, eight alternative projections of the population of British regions are produced (see Table 24 for the full list).

The results of the projections are assessed at census date 1976 through the calculation of three goodness of fit statistics. Table 23 shows the calculations for the C1V (the emigrant adjustment method, variable rates) projection. The simple difference between estimated and projected population is calculated; the absolute difference is computed; and the absolute difference is computed as a percentage of the estimate. The sum totals of these statistics for Great Britain enable us to judge between projections. The simple difference alone may mask large cancelling deviations among the regions, the absolute difference measure corrects for this but may be unduly influenced by a large region; the percentage absolute difference measure gives equal weight to each region. Table 23 is presented in terms of the 10 standard regions of the original analysis rather than in terms of our 4 sections of Great Britain because aggregation in this context does not make sense.

Table 24 displays the three overall goodness of fit statistics for the eight projections. The variable rate projections are clearly better than the fixed as one might have expected and the constrained projections are better than the unconstrained. The backcast adjustment method

Table 23. Goodness of fit calculations for the C1V projection, 1976 (1000s)

Region	Estimate	Projection	Difference	|Difference|	%|Difference|
North	3122.6	3101.4	21.1	21.1	0.68
Yorks. & Humb.	4893.7	4848.1	45.6	45.6	0.93
North West	6557.7	6582.6	-24.8	24.8	0.38
East Midlands	3732.4	3728.1	4.3	4.3	0.12
West Midlands	5167.1	5177.2	-10.2	10.2	0.20
East Anglia	1799.2	1783.8	15.4	15.4	0.86
South East	16898.6	16980.5	-81.9	81.9	0.48
South West	4249.5	4158.7	90.7	90.7	2.14
Wales	2766.3	2726.0	40.1	40.1	1.45
Scotland	5197.7	5147.7	50.0	50.0	0.96
G.B. Total	54384.8	54234.2	150.6	384.4	8.20

Table 24. Calibration statistics for British regions, 1970-76, for 1976 population

Model run	Difference in total	Sum of absolute differences	Sum of absolute % differences	Type of run	Status of birth & death rates & external migrants
UF	398.9	683.2	9.53	Unconstrained	Fixed
C1F	504.7	612.6	9.81	Constrained 1	"
C2F	418.7	554.1	9.17	" 2	"
C3F	415.8	626.0	8.58	" 3	"
UV	-168.2	393.0	11.39	Unconstrained	Variable
C1V	-150.6	384.4	8.20	Constrained 1	"
C2V	-150.6	387.8	8.15	" 2	"
C3V	-150.8	539.0	10.13	" 3	"

appears to fair worst of the three procedures and there is little to choose between the emigrant adjustment and initial population adjustment method. The former method was on balance chosen as more convenient since it involved retaining the official population estimates whereas the latter method would have involved their successive revision. We have now arrived at the third box in column three of Figure 5.

4.5 Estimation of the time series of accounts for 1971-76

The time series of accounts was then generated using the emigrant adjusted constraints. The appropriate input data on births, deaths, populations and external migrants was assembled for each year and a constrained set of accounts were produced using the internal migration rates and internal infant migration rates of the preceding year. The results are reproduced in Appendix 2.

5. Uses of multistate demographic accounts

Accounts are devices for displaying the historical relationships in terms of population flows between demographic states. They enable us to understand better the pace and direction of demographic change. They have been used in carrying out educational projections (Stone, 1971), multiregional population projections (Rees, 1976, 1977b) and in computing multiregional life tables (Rogers, 1975; Willekens and Rogers, 1978; Rees, 1978a), although in the latter application only the internal portion of the accounts matrix is used.

As yet demographic accounting has had little impact in either national statistical offices or at local or regional levels (see Baxter and Williams, 1978 for comments). The usual objection posed is that the preparation of accounts tables is too complex and time consuming an exercise. It is hoped that this paper has served to dispell that view in part and that with the improvement of computer packages for multistate demographic accounting preparation of demographic accounts will become a common prior step in much future-oriented demographic analysis.

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APPENDIX 1. East Anglia and South East region accounts, 1966-71, persons: by cohort

BIRTH TO 0-4

Existence / Birth	Survival aged 0-4 EA	SE	RB	RW	Death 0-4 EA	SE	RB	RW	Totals
East Anglia	112592	4201	3658	2330	1898	39	34	18	124770
South East	6519	1243894	35213	44327	50	23519	324	402	1352048
Rest of Britain	5889	30178	2834255	46972	71	276	54551	444	2975636
Rest of World	3426	24610	31471	0	28	225	298	0	60058
Totals	131426	1302683	2903597	93629	2047	24059	55207	864	4512512

0-4 TO 5-9

Existence: 0-4 / 5-9	Survival aged 5-9 EA	SE	RB	RW	Death 0-4, 5-9 EA	SE	RB	RW	Totals
East Anglia	108108	5759	6890	4566	476	11	16	9	125605
South East	11131	1249390	58954	84055	22	5489	142	171	1409274
Rest of Britain	8369	52833	2892220	89577	18	109	14227	215	3058068
Rest of World	6900	46268	58293	0	14	90	140	0	113704
Totals	135048	1356130	3016317	177898	530	5708	14525	395	4706651

5-9 TO 10-14

Existence: 5-9 / 10-14	Survival aged 10-14 EA	SE	RB	RW	Death 5-9, 10-14 EA	SE	RB	RW	Totals
East Anglia	100217	3972	4578	4011	171	4	4	4	112961
South East	7513	1112234	39793	77256	6	1720	33	56	1238611
Rest of Britain	6219	37861	2651944	83011	5	28	4459	69	2783506
Rest of World	5840	45949	53146	0	5	34	45	0	105019
Totals	119699	1200016	2749461	164278	187	1786	4541	129	4240097

10-14 TO 15-19

Existence: 10-14 / 15-19	Survival aged 15-19 EA	SE	RB	RW	Death 10-14, 15-19 EA	SE	RB	RW	Totals
East Anglia	96606	3893	3673	3334	252	5	5	5	107773
South East	5710	1015938	31756	63870	7	2309	37	72	1119789
Rest of Britain	5814	46077	2394405	68014	8	51	5785	85	2520237
Rest of World	3800	49389	48969	0	5	85	60	0	102278
Totals	111930	1115297	2478803	135218	272	2510	5887	160	3850077

15-19 TO 20-24

Existence: 15-19 / 20-24	Survival aged 20-24 EA	SE	RB	RW	Death 15-19, 20-24 EA	SE	RB	RW	Totals
East Anglia	99103	9396	7286	4827	433	14	14	8	121081
South East	12590	1128627	71702	91847	24	4019	131	148	1309088
Rest of Britain	10725	119097	2485220	94074	20	192	9651	177	2719156
Rest of World	8830	105136	64158	0	18	160	116	0	178418
Totals	131248	1362256	2628366	190748	495	4385	9912	333	4327743

APPENDIX 1.. Continued

20-24 TO 25-29

Existence: 20-24 \ 25-29	Survival aged 25-29 EA	SE	RB	RW	Death 20-24,25-29 EA	SE	RB	RW	Totals
East Anglia	79620	7578	8141	5296	334	13	15	10	101007
South East	14408	984059	79740	101785	26	3691	148	175	1184032
Rest of Britain	9440	84510	2074448	107473	18	145	8056	208	2284298
Rest of World	7790	88045	70123	0	14	149	134	0	166255
Totals	111258	1164192	2232452	214554	392	3998	8353	393	3735592

25-29 TO 30-34

Existence: 25-29 \ 30-34	Survival aged 30-34 EA	SE	RB	RW	Death 25-29,30-34 EA	SE	RB	RW	Totals
East Anglia	75425	4895	5505	3557	312	10	12	7	89723
South East	9799	912460	57623	81742	19	3957	125	164	1065889
Rest of Britain	7129	51816	1931915	87173	13	105	8606	191	2086948
Rest of World	6340	54686	54385	0	12	110	119	0	115652
Totals	98695	1023857	2049428	172472	356	4182	8862	362	3358212

30-34 TO 35-39

Existence: 30-34 \ 35-39	Survival aged 35-39 EA	SE	RB	RW	Death 30-34,35-39 EA	SE	RB	RW	Totals
East Anglia	78257	3697	4445	2544	425	11	14	6	89399
South East	7366	905165	41016	55390	18	5372	125	154	1014606
Rest of Britain	4864	37201	1926934	59043	12	105	12038	184	2040381
Rest of World	4920	37919	35351	0	13	107	108	0	78418
Totals	95407	983982	2007746	116977	468	5595	12285	344	3222804

35-39 TO 40-44

Existence: 35-39 \ 40-44	Survival aged 40-44 EA	SE	RB	RW	EA	SE	RB	RW	Totals
East Anglia	85217	2859	3237	2133	746	14	18	9	94233
South East	6039	961140	32917	41027	25	9267	173	189	1050777
Rest of Britain	4422	31037	2061548	43673	19	144	21953	231	2163027
Rest of World	2730	28287	26848	0	11	131	140	0	58147
Totals	98408	1023323	2124550	86833	801	9556	22284	429	3366184

40-44 TO 45-49

Existence: 40-44 \ 45-49	Survival aged 45-49 EA	SE	RB	RW	EA	SE	RB	RW	Totals
East Anglia	91858	2640	2416	1497	1341	20	22	11	99805
South East	5512	1031932	27662	28717	38	16024	261	212	1110358
Rest of Britain	5550	26522	2227808	30207	36	200	42591	286	2333200
Rest of World	1440	20178	18812	0	10	153	179	0	40772
Totals	104360	1081272	2276698	60421	1425	16397	43053	509	3584135

APPENDIX 1. Continued

45-49 TO 50-54

Existence 45-49	50-54	Survival aged 50-54 EA	SE	RB	RW	Death 45-49,50-54 EA	SE	RB	RW	Totals
	East Anglia	85541	1964	1763	991	2065	28	27	12	92391
	South East	4737	973153	23445	19024	56	26602	353	249	1047619
	Rest of Britain	5017	19553	2054382	19954	51	260	62885	306	2162408
	Rest of World	1080	14026	11906	0	13	189	183	0	27397
Totals		96375	1008696	2091496	39969	2185	27079	63448	567	3329815

50-54 TO 55-59

Existence 50-54	55-59	Survival aged 55-59 EA	SE	RB	RW	Death 50-54,55-59 EA	SE	RB	RW	Totals
	East Anglia	90042	1274	1031	649	3576	28	27	12	96639
	South East	4612	1026101	23250	12506	87	45369	566	258	1112749
	Rest of Britain	4800	14992	2101598	13023	77	319	107926	328	2243063
	Rest of World	590	8983	8022	0	12	194	206	0	18007
Totals		100044	1051350	2133901	26178	3752	45910	108725	598	3470458

55-59 TO 60-64

Existence 55-59	60-64	Survival aged 60-64 EA	SE	RB	RW	Death aged 55-59,60-64 EA	SE	RB	RW	Totals
	EA	88193	1003	967	435	5906	33	39	14	96590
	SE	6428	975196	25097	8539	204	71524	998	276	1088262
	RB	1819	12220	2008920	8685	57	405	170133	343	2202582
	RW	310	5966	5401	0	10	204	216	0	12107
Totals		96750	994385	2040385	17659	6177	72166	171386	633	3399541

60-64 TO 65-69

Existence 60-64	65-69	Survival aged 65-69 EA	SE	RB	RW	Death aged 60-64,65-69 EA	SE	RB	RW	Totals
	EA	77460	794	1284	325	8936	33	99	17	88948
	SE	4638	806332	27368	6014	291	99003	1882	333	945861
	RB	2824	11886	1703828	6178	152	684	241293	422	1967267
	RW	190	4344	4844	0	12	247	331	0	9968
Totals		85112	823356	1737324	12517	9391	99967	243605	772	3012044

65-69 TO 70-74

Existence 65-69	70-74	Survival aged 70-74 EA	SE	RB	RW	Death aged 65-69,70-74 EA	SE	RB	RW	Totals
	EA	60783	652	1105	177	11580	44	128	15	74484
	SE	3379	595172	13168	3183	298	118223	1439	286	735148
	RB	2480	7955	1268768	3238	178	745	289654	352	1573370
	RW	140	2536	3021	0	13	227	321	0	6258
Totals		66782	606315	1286062	6598	12069	119239	291542	653	2389260

APPENDIX 1. Continued

70-74 TO 75

70-74 \ 75-79		Survival aged 75-79				Death aged 70-74, 75-79				
		EA	SE	RB	RW	EA	SE	RB	RW	Totals
Existence	EA	41145	492	876	87	13852	63	165	13	56693
	SE	2008	408765	6800	1385	286	141859	1146	219	562468
	RB	1710	5950	831111†	1661	209	948	309352	283	1151224
	RW	79	1222	1571	0	12	194	258	0	3336
Totals		44942	416429	840358	3133	14359	143064	310921	515	1773721

75+ TO 80+

75+ \ 80+		Survival aged 80+				Death aged 75+,80+				
		EA	SE	RB	RW	EA	SE	RB	RW	Totals
Existence	EA	42545	549	754	86	36338	176	311	29	80788
	SE	2123	420930	6384	1782	702	366750	2509	615	801795
	RB	1729	6083	713197	1501	538	2150	712844	593	1438635
	RW	81	1254	1421	0	28	441	554	0	3779
Totals		46478	428816	721756	3369	37606	369517	716218	1237	2324997

ALL AGE ACCOUNTS

Initial states \ Final states		Survival at c.d. 1971				Death 1966-71				
		EA	SE	RB	RW	EA	SE	RB	RW	Totals
Existence	EA	1300120	51397	53941	34315	86743	507	916	181	1528120
	SE	108033	14506494	566655	678122	2109	921268	10068	3577	16796326
	RB	83321	565593	31328246	716485	1411	6590	2021453	4271	34727370
	RW	51060	516188	466261	0	202	2694	3110	0	1039515
Birth	EA	112592	4201	3658	2330	1898	39	34	18	124770
	SE	6519	1243694	33213	44327	50	23519	324	402	1352048
	RB	8889	30178	2834255	46972	71	276	54551	444	2975636
	RW	3426	24610	31471	0	28	225	298	0	60058
Totals		1673960	16942355	35317700	1522551	92512	955118	2090754	8893	58603843

APPENDIX 1. Continued: births classified by age of mother

Mother's age 10-14

0-4 / Birth	Survival aged 0-4				Death aged 0-4				Totals
	EA	SE	RB	RW	EA	SE	RB	RW	
EA	3297	123	107	69	56	1	1	0	3654
SE	162	30914	826	1102	2	585	8	10	33609
RB	270	915	85905	1426	2	8	1656	13	90195
RW	100	612	955	0	1	6	9	0	1683
Totals	3829	32564	87793	2597	61	600	1674	23	129141

Mother's age 15-19

0-4 / Birth	Survival aged 0-4				Death aged 0-4				Totals
	EA	SE	RB	RW	EA	SE	RB	RW	
EA	29249	1091	951	605	493	10	9	0	32413
SE	1509	287912	7689	10261	12	5444	75	93	312995
RB	2221	7542	707288	11738	18	69	13632	111	742619
RW	889	5697	7865	0	7	52	75	0	14585
Totals	33868	302242	723793	22604	530	5575	13791	209	1102612

Mother's age 20-24

0-4 / Birth	Survival aged 0-4				Death aged 0-4				Totals
	EA	SE	RB	RW	EA	SE	RB	RW	
EA	40517	1512	1316	839	683	14	12	7	44900
SE	2289	436624	11659	15562	17	8257	114	141	474663
RB	3055	10373	972788	16145	25	95	18749	154	1021384
RW	1233	8640	10818	0	10	79	102	0	20882
Totals	47094	457149	996581	32546	935	8445	18977	302	1561829

Mother's age 25-29

0-4 / Birth	Survival aged 0-4				Death aged 0-4				Totals
	EA	SE	RB	RW	EA	SE	RB	RW	
EA	23833	889	775	493	402	8	7	4	26411
SE	1505	287004	7664	10229	12	5427	75	93	312009
RB	1923	6529	612344	10162	16	60	11802	96	642932
RW	725	5679	6809	0	6	51	64	0	13334
Totals	27986	300101	627592	20884	436	5546	11948	193	994686

APPENDIX 1. Continued

Mother's age 30-34

Birth \ 0-4	Survival aged 0-4 EA	SE	RB	RW	Death aged 0-4 EA	SE	RB	RW	Totals
EA	10692	399	347	221	180	4	3	2	11848
SE	718	137060	3660	4885	5	2592	35	44	148999
RB	936	3178	302043	4947	7	29	5746	46	316932
RW	326	2712	3314	0	3	25	31	0	6411
Totals	12672	143349	309364	10053	195	2650	5815	92	484190

Mother's age 35-39

Birth \ 0-4	Survival aged 0-4 EA	SE	RB	RW	Death aged 0-4 EA	SE	RB	RW	Totals
EA	4171	156	135	86	71	2	2	0	4623
SE	282	53830	1438	1919	2	1018	14	17	58520
RB	401	1362	127690	2119	3	13	2461	20	134069
RW	127	1065	1420	0	1	10	14	0	2637
Totals	4981	56413	130683	4124	77	1043	2491	37	199849

Mother's age 40-44

Birth \ 0-4	Survival aged 0-4 EA	SE	RB	RW	Death aged 0-4 EA	SE	RB	RW	Totals
EA	791	29	26	17	13	0	0	0	876
SE	51	9883	264	352	0	187	3	4	10744
RB	79	267	25054	416	0	2	483	4	26305
RW	24	195	278	0	0	2	3	0	502
Totals	945	10374	25622	785	13	191	489	8	38427

Mother's age 45-49

Birth \ 0-4	Survival aged 0-4 EA	SE	RB	RW	Death aged 0-4 EA	SE	RB	RW	Totals
EA	42	2	1	0	0	0	0	0	45
SE	3	467	13	17	0	9	0	0	509
RB	4	12	1143	19	0	0	22	0	1200
RW	2	10	12	0	0	0	0	0	24
Totals	51	491	1169	36	0	9	22	0	1778

Source: Rees, 1978, Appendix 2.

APPENDIX 2. Best fit mid year accounts, sections of G.B., 1970-76 (1000s)

1971 / 1970		Survival					Death					Totals
		N	M	S	CF	A	N	M	S	CF	A	
Existence	North	14164.1	43.1	80.6	27.3	81.9	177.7	0.2	0.5	0.2	0.5	14576.0
	Midlands	41.3	8428.1	69.5	15.9	51.5	0.3	92.7	0.4	0.1	0.3	8700.0
	South	75.8	77.2	21982.2	47.7	244.8	0.5	0.4	256.8	0.3	1.4	22687.0
	Celtic F.	26.7	17.8	46.5	7683.9	59.1	0.2	0.1	0.3	95.9	0.4	7930.7
	Abroad	60.1	41.6	240.1	37.5	0	0.4	0.2	1.4	0.2	0	381.4
Birth	North	238.2	0.4	0.7	0.2	0.7	1.5	0.0	0.0	0.0	0.0	241.5
	Midlands	0.4	146.8	0.6	0.1	0.4	0.0	0.8	0.0	0.0	0.0	149.2
	South	0.6	0.6	344.7	0.4	1.9	0.0	0.0	2.0	0.0	0.0	350.1
	Celtic F.	0.2	0.1	0.4	127.8	0.5	0.0	0.0	0.0	0.8	0.0	129.8
	Abroad	0.5	0.4	1.8	0.3	0	0.0	0.0	0.0	0.0	0.0	3.0
Totals		14607.7	8756.1	22767.0	7941.0	440.7	180.5	94.5	261.3	97.5	2.6	55148.8

1972 / 1971		Survival					Death					Totals
		N	M	S	CF	A	N	M	S	CF	A	
Existence	North	14199.4	43.5	81.8	27.7	73.5	180.5	0.2	0.5	0.2	0.5	14607.7
	Midlands	41.3	8490.8	70.0	15.9	42.7	0.3	94.4	0.4	0.1	0.2	8756.1
	South	75.3	77.5	22083.3	47.3	221.1	0.5	0.4	260.0	0.3	1.3	22767.0
	Celtic F.	26.7	18.0	47.2	7693.9	57.1	0.2	0.1	0.3	97.2	0.4	7941.0
	Abroad	56.2	43.2	242.0	37.2	0	0.4	0.2	1.4	0.2	0	380.0
Birth	North	226.7	0.4	0.7	0.2	0.6	1.4	0.0	0.0	0.0	0.0	230.0
	Midlands	0.3	140.8	0.6	0.1	0.3	0.0	0.8	0.0	0.0	0.0	143.0
	South	0.6	0.6	333.6	0.4	1.6	0.0	0.0	1.9	0.0	0.0	338.7
	Celtic F.	0.2	0.1	0.4	122.1	0.4	0.0	0.0	0.0	0.8	0.0	124.0
	Abroad	0.4	0.4	1.8	0.3	0	0.0	0.0	0.0	0.0	0.0	2.9
Totals		14627.2	8815.2	22861.3	7945.0	397.4	183.1	96.2	264.5	98.8	2.3	55291.2

1973 / 1972		Survival					Death					Totals
		N	M	S	CF	A	N	M	S	CF	A	
Existence	North	14225.1	42.7	81.9	29.3	63.8	183.0	0.2	0.5	0.2	0.5	14627.2
	Midlands	42.4	8546.6	73.0	17.5	38.2	0.3	96.5	0.4	0.1	0.2	8815.2
	South	76.0	76.4	22174.5	50.2	218.1	0.5	0.4	263.7	0.3	1.3	22861.3
	Celtic F.	25.4	16.6	44.9	7708.9	49.3	0.2	0.1	0.3	99.0	0.3	7945.0
	Abroad	54.5	45.0	243.3	40.7	0	0.3	0.3	1.4	0.3	0	385.9
Birth	North	207.4	0.4	0.7	0.2	0.5	1.3	0.0	0.0	0.0	0.0	210.4
	Midlands	0.4	130.5	0.6	0.1	0.3	0.0	0.7	0.0	0.0	0.0	132.6
	South	0.6	0.6	312.8	0.4	1.5	0.0	0.0	1.8	0.0	0.0	317.7
	Celtic F.	0.2	0.1	0.4	113.4	0.4	0.0	0.0	0.0	0.7	0.0	115.2
	Abroad	0.4	0.3	1.7	0.3	0	0.0	0.0	0.0	0.0	0	2.7
Totals		14632.3	8859.2	22933.8	7961.0	372.0	185.6	98.2	268.1	100.6	2.2	55413.2

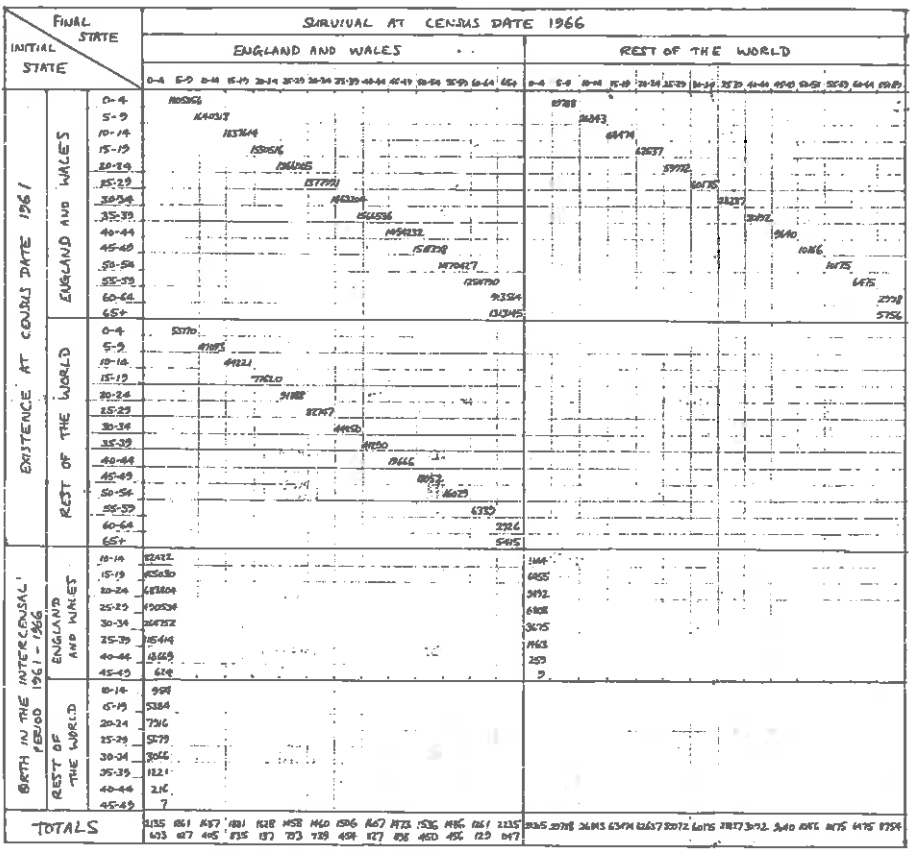
APPENDIX 2. Continued

1973 \ 1974		Survival N	M	S	CF	A	Death N	M	S	CF	A	Totals
Existence	North	14236.6	44.4	83.0	29.6	56.2	181.2	0.2	0.5	0.2	0.4	14632.3
	Midlands	41.2	8591.4	70.5	16.7	42.1	0.3	96.4	0.4	0.1	0.2	8859.2
	South	75.0	78.7	22241.9	50.2	222.4	0.5	0.4	263.1	0.3	1.3	22933.8
	Celtic F.	25.0	17.3	45.0	7736.8	37.3	0.2	0.1	0.3	98.8	0.2	7961.0
	Abroad	47.1	39.2	192.8	32.4	0	0.3	0.2	1.1	0.2	0	313.3
Birth	North	192.6	0.4	0.7	0.2	0.6	1.2	0.0	0.0	0.0	0.0	195.7
	Midlands	0.3	121.8	0.6	0.1	0.5	0.0	0.7	0.0	0.0	0.0	124.1
	South	0.6	0.6	294.8	0.4	2.0	0.0	0.0	1.7	0.0	0.0	300.1
	Celtic F.	0.2	0.1	0.4	107.2	0.5	0.0	0.0	0.0	0.7	0.0	109.1
	Abroad	0.3	0.3	1.3	0.2	0	0.0	0.0	0.0	0.0	0.0	2.1
Totals		14619.0	8894.1	22930.9	7973.8	361.6	183.6	98.1	267.1	100.3	2.1	55430.7

1974 \ 1975		Survival N	M	S	CF	A	Death N	M	S	CF	A	Totals
Existence	North	14213.8	42.4	81.0	29.7	71.4	179.4	0.2	0.5	0.2	0.4	14619.0
	Midlands	43.3	8619.0	73.1	17.9	43.4	0.3	96.4	0.4	0.1	0.2	8894.1
	South	77.1	76.9	22233.3	51.4	227.1	0.5	0.4	262.7	0.3	1.3	22930.9
	Celtic F.	25.2	16.4	44.2	7731.0	58.2	0.2	0.1	0.3	97.9	0.4	7973.8
	Abroad	56.1	33.7	217.9	37.3	0	0.3	1.9	1.3	0.2	0	347.1
Birth	North	182.3	0.4	0.7	0.2	0.5	1.1	0.0	0.0	0.0	0.0	185.1
	Midlands	0.4	114.2	0.6	0.2	0.3	0.0	0.6	0.0	0.0	0.0	116.2
	South	0.6	0.6	279.5	0.4	1.4	0.0	0.0	1.6	0.0	0.0	284.1
	Celtic F.	0.2	0.1	0.4	102.3	0.4	0.0	0.0	0.0	0.6	0.0	104.0
	Abroad	0.4	0.2	1.4	0.2	0	0.0	0.0	0.0	0.0	0.0	2.2
Totals		14599.2	8903.9	22932.0	7970.5	402.6	181.8	98.0	266.8	99.4	2.4	55456.6

1975 \ 1976		Survival N	M	S	CF	A	Death N	M	S	CF	A	Totals
Existence	North	14195.5	41.7	83.5	30.1	68.9	178.1	0.2	0.5	0.2	0.4	14599.2
	Midlands	44.1	8624.4	77.0	18.5	40.6	0.3	98.3	0.5	0.1	0.2	8903.9
	South	74.6	73.1	22252.9	51.2	206.8	0.5	0.4	271.0	0.3	1.2	22932.0
	Celtic F.	24.5	15.7	44.4	7733.1	53.4	0.2	0.1	0.3	98.5	0.3	7970.5
	Abroad	53.9	33.6	222.4	37.7	0	0.3	1.9	1.3	0.2	0	349.8
Birth	North	174.4	0.3	0.7	0.2	0.4	1.1	0.0	0.0	0.0	0.0	177.1
	Midlands	0.4	108.7	0.7	0.2	0.3	0.0	0.6	0.0	0.0	0.0	110.8
	South	0.6	0.6	267.4	0.4	1.2	0.0	0.0	1.6	0.0	0.0	271.8
	Celtic F.	0.2	0.1	0.4	100.1	0.3	0.0	0.0	0.0	0.6	0.0	101.8
	Abroad	0.3	0.2	1.3	0.2	0	0.0	0.0	0.0	0.0	0.0	2.1
Totals		14568.5	8898.5	22950.6	7971.9	371.9	180.4	99.8	275.1	100.0	2.2	55418.9

APPENDIX 3. Age disaggregated demographic accounts for females in England and Wales, 1961-1966: full version



continuation Appendix 3