A METHOD TO ESTIMATE THE IMPACT OF MIGRATION ON THE SEX AND AGE STRUCTURE OF A POPULATION WITH AN APPLICATION TO THE CASE OF GREECE

1951 — 1970

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Introduction

The difficulties in obtaining reliable data on migration have been stressed in the past (Isaac, 1947) and more recently (Adams, 1971). To overcome some of these difficulties the combined use of flow and census data was recommended by Jaffe (1971). The author (1974), in a paper concerning demographic changes in West Germany, has put that recommendation into practice by disaggregating the «balancing equation» into two parts : one referring to the native and the other to the foreign population of a country.

In this paper we disaggregate the «balancing equation» by sex and into age - groups by taking the nationals and the foreigners living in a country together. This disaggregation requires a method of allocating deaths occuring during an intercensal period to age - groups at the end of the period. After introducing the necessary notation we develop that method and then obtain estimates of deaths and net migration for the case of Greece in the two post - war intercensal periods 1951 - 60 and 1961 - 1970. On the basis of these estimates we calculate the impact of death and net migration on the age and sex structure of the Greek population.

A method of allocating emigration (similar to that for deaths) to age - groups

is then developed and applied to the case of Greece for the second intercensal period (1961 - 70). This enables us to obtain estimates of immigration by age and sex for that period. The reliability of these estimates is checked using migration data from West - German sources.

In the Conclusion we suggest the directions in which the method used in the paper can be improved and indicate the need for collection and publication of more detailed data on deaths and emigration.

I. Notation and the Disaggregated «Balancing Equation»

To avoid using three subscripts we will define our variables and develop our methods on the understanding that they apply equally to males and females.

The stock data required for the application of the method developed here are those given in two successive general population censuses disaggregated by sex and in 5 - year age - groups. Taking thirteen of these age - groups (0 - 4, 5 - 9, ..., 60 - 64) and a «residual» age - group 65 + and denoting by :

P_{ij} = Population in age - group j of population census i (i = 1 for the census at the beginning and i = 2 for the census at the end of the decade) (1)

we have

$$P_i = \sum_{j=1}^{14} P_{ij} = \text{Total population of census i} \qquad (2)$$

The flow data required are those on births, deaths and emigration. For births we have data on :

B_t = Number of live births in year t (t = 1,2,. . . . ,10 for 1951, 2,. . . . ,1960 or 1961,2. . . . ,1970 depending on which intercensal period (or decade) we are considering). (3)

From these data we define the «base» values (i = 1) of the two age - groups which did not exist at the beginning of the period :

$$P_{1, -1} = \sum_{t=6}^{10} B_t = \text{Number of live births in the last five years of the decade} \quad (4)$$

$$P_{1,0} = \sum_{t=1}^{5} B_t = \text{Number of live births in the first five years of the decade,} \qquad (5)$$

and, of course,

$$B = P_{1,0} + P_{1, -1} = \sum_{t=1}^{10} B_t = \text{Total number of live births during the decade.} \qquad (6)$$

For the deaths the published data are on :

d_{tk} = deaths in year t of children aged k (k = 0,1,2,3,4,) in that year, and $\quad$ (7)

D_{tr} = deaths in year t of people in age-group r in that year (r = 2,3,.... for age-groups 5-9, 10-14....) $\qquad$ (8)

From these data we will construct the sub-aggregates :

DG_j = Number of deaths of people belonging to age-group j (j = 1,2,....,14) at the end of the intercensal period which occured during the decade, where $\qquad$ (9)

$$DG_{14} = D - \sum_{j=1}^{13} DG_j \qquad (10)$$

and where

D = Total number of deaths during the decade. $\qquad$ (11)

For Emigration the published data are on :

E_{tr} = number of emigrants in year t belonging to age-group r in that year. $\qquad$ (12)

From these data the following sub-aggregates will be constructed :

EG_j = Number of Emigrants belonging to age-group j (j = 1,2,....,14) at the end of the period who emigrated during the decade $\qquad$ (13) where

$$EG_{14} = E - \sum_{j=1}^{13} EG_j \qquad (14)$$

and where

E = Total number of Emigrants during the decade. $\qquad$ (15)

With the notation defined in (1) to (15) the aggregate «balancing equation» is

$$P_2 = P_1 + B - D - NM \qquad (16)$$

where

NM = E — I = Total Net Migration during the decade, $\qquad$ (17)

and

I = Total Immigration during the decade. $\qquad$ (18)

As deaths will be given with a positive sign, we have defined net migration so that if (17) is greater, equal or less than zero we have, respectively, net emigration, zero net migration or net immigration.

In a similar fashion the disaggregated «balancing equation» is

$$P_{2,j} = P_{1,j-2} - DG_j - NMG_j \quad ; \quad (j = 1,2,\ldots\ldots,14) \tag{19}$$

where

$$NMG_j = EG_j - IG_j = \text{Net migration of people belonging to age-group}$$
$$j \text{ at the end of the period,} \tag{20}$$

and

$$IG_j = \text{Number of people belonging to age-group } j \text{ at the end of the period}$$
$$\text{who immigrated during the decade.} \tag{21}$$

What has been said about the sign of (17) holds also for (20).

In what follows we first develop the method to allocate deaths to age-groups and then, using Greek census and flow data, calculate the DG_j ($j = 1,2,\ldots,14$) and, by solving (19), the NMG_j ($j = 1,2,\ldots,14$) for the intercensal periods 1951 – 60 and 1961 - 70. Having obtained the NMG_j we develop the method to allocate emigration to age-groups at the end of the period and then, using the results on NMG_j and Greek data for the period 1961 - 70, calculate immigration by age and sex by solving (20) for IG_j.

II. The Method of Allocating Deaths to Age-Groups

The method we are developing in this section assumes the existence of data on deaths, disaggregated by sex, for infants, children aged 1,2,3 and 4 (the d_{tk}) and for 5-year age-groups (the D_{tr}) starting from the age-group 5 - 9.

The full utilisation of this information requires the construction of special formulae for the first three age-groups at the end of the period and a general formula for the next ten.

The first three age-groups at the end of the period include children who either are or have been infants (aged less than one year) during the intercensal period. As infant deaths are the most important for the first two of these age-groups we adopt the well-known formula (see, for example, Siambos, 1969, p. 32) whereby 75 % of the deaths of children less than 1 year old (k = 0) recorded in year t are deaths of children born in that year and the remaining 25 % of the same deaths refer to children born in the previous year.

Assuming, further, that the deaths of children aged 1 (and similarly the deaths of children aged 2,3 and 4) are equally spread throughout the year in which they are occuring we allocate 50 % of the deaths of children aged k + 1 (k = 0,1,2,3) during year t to the children aged k in the beginning of year t and the remaining 50 % to the children aged k in the beginning of year t - 1 (see, also, Siambos, 1973, p.138). Thus the number of deaths of children belonging to age-group 1 (0 - 4) at the end of the intercensal period which occured during the decade is :

$$\mathbf{D}G_t = 0.75d_{10,0} + \sum_{t=6}^{9} (0.75d_{t0} + 0.25d_{t+1,0}) + \sum_{t=7+k}^{10} \sum_{k=1}^{3} d_{tk} +$$

$$+ 0.50 \sum_{s=7}^{10} d_{s,s-6} \tag{22}$$

For the age - group 2 (5 - 9) at the end of the period we follow the logic on which (22) is based for $t = 1,2,3,4,$ and 5. When we move to $t = 6$ we note that some of the children born in year 1 will become 5 in that year. Assuming :

(i) that the deaths recorded for the age - group 2 (5 - 9) are equally spread among the children aged 5,6,7,8 and 9 and

(ii) carrying the assumption mentioned above that the deaths are equally spread among the months of the year, we allocate 10 % of D_{62} to age - group 5 - 9 at the end of the period. Some of the children born in year 1 and all the children born after year 1 will be less than 5 years old in year 6. For these children we allocate the deaths recorded in year 6 for children aged 0,1,2,3, and 4 following the principle on which (22) is based. In year 7 all the children born in year 2 will be in the age-group 2 (5 - 9). We therefore allocate 30 % of D_{72} to the children belonging to the age - group 5 - 9 at the end of the intercensal period. For the children aged 1,2,3 and 4 we follow what has been said before. Proceeding in the same way for years 8,9 and 10 we obtain the following formula for the number of deaths of children belonging to age - group 2 (5 - 9) at the end of the period which occured during the decade.

$$\mathbf{D}G_2 = \sum_{t=1}^{5} (0.75d_{t0} + 0.25d_{t+1,0}) + \sum_{t=k+2}^{6} \sum_{k=1}^{4} d_{tk} + \sum_{t=7}^{9} \sum_{k=t-5}^{6} d_{tk} +$$

$$+ 0.50 \sum_{s=2}^{5} d_{s,s-1} + 0.50 \sum_{s=7}^{10} d_{s,s-6} + \sum_{t=6}^{10} \{0.10 + (t - 6) 0.20\} D_{t2} \tag{23}$$

Some of the children born in the 5 - year period before year 1 will be less than 1 year old in that year. Hence 25 % of d_{10} refers to that age - group. Most of the children born in that period will be aged 1,2,3, and 4 years old in year 1 and for these we follow the logic on which (22) is based. Finally (still in year 1) some of the children born 5 years before year 1 will become 5 in that year. For these children we allocate 10 % of the deaths of children aged 5 - 9 recorded in year 1 (the D_{12}). Moving to year 2 all the children born 5 years before year 1 and some of the children born 5 years before year 2 will be in the age - group 5 - 9 in year 2 while the rest will be aged 1,2,3 and 4 years old. Hence for year 2 (as well as for years 3,4 and 5) we follow the logic on which (23) is based. In year 6 all the children born in the 5 - year period before year 1 will be in the age - group 5 - 9 and some of the children born 5 years before year 1 will move to the age - group 10 - 14. For these children (i.e. those in the age - group 0 - 4 at the beginning of the period) we allocate 90 % of D_{62} and 10 % of D_{63}. In year 7, following the same reasoning,

we allocate 70 % of D_{72} and 30 % of D_{73} and so on up to year 10. Hence the number of deaths of children belonging to the age - group 3 (10 - 14) at the end of the period which occured during the decade will be :

$$DG_3 = 0.25d_{10} + \sum_{t=1}^{4} \sum_{k=t}^{4} d_{tk} + 0.50 \sum_{s=2}^{5} d_{s,s-1} + \sum_{t=1}^{5} \{ 0.10 + (t-1) 0.20 \} D_{t2} +$$

$$+ \sum_{t=6}^{10} [\{ 0.10 + (10-t) 0.20 \} D_{t2} + \{ 0.10 + (t-6) 0.20 \} D_{t3}] \quad (24)$$

For the age - groups 15 - 19, 20 - 24, ..., 60 - 64 (j = 4,5,....,13) at the end of the period we proceed in a way similar to that followed for the age group 10 - 14 from year 6 onwards i.e. :

In year 1 we allocate to age - group j (= r) at the end (i.e. the age - group j - 2 (= r - 2) at the beginning) of the period 90 % of the deaths of people in the age - group r - 2 and 10 % of the deaths of people in the age - group r - 1 recorded in the year.

In year 2 the percentages are 70 % of $D_{2,r-2}$ and 30 % of $D_{2,r-1}$, in year 3 50 % of $D_{3,r-2}$ and 50 % of $D_{3,r-1}$ and so on up to and including year 5.

In year 6 all the children in age - group r - 2 at the beginning of the period will be in the age - group r - 1 and some will move to the age - group r. Hence we allocate to the age - group r at the end of the period 90 % of $D_{6,r-1}$ and 10 % of $D_{6,r}$. In year 7 we allocate 70 % of $D_{7,r-1}$ and 30 % of $D_{7,r}$ and so on. The formula, therefore, giving the number of deaths of people belonging to age - group r at the end of the period which occured during the decade is :

$$DG_r = \sum_{t=1}^{5} [\{ 0.10 + (5-t) 0.20 \} D_{t,r-2} + \{ 0.10 + (t-1) 0.20 \} D_{t,r-1}] +$$

$$+ \sum_{t=6}^{10} [\{ (0.10 + (10-t) 0.20 \} D_{t,r-1} + \{ (0.10 + (t-6) 0.20 \} D_{t,r}]$$

$$\text{for } r = 4,5, \ldots \ldots ,13 \quad (25)$$

As the d_{tk} (k = 0,1,2,3,4) and the D_{tr} (r = 2,3,....) for t = 1,2,..., 10 are changing over time it is very difficult to give diagrammatically the method summarised in formulae (22) (23), (24) and (25). Despite this difficulty and in order to make the formulae easier to understand we give in diagram 1 a schematic representation of the method for allocating deaths to the first three age - groups and to the age - group 15 - 19 which is typical of the age - groups 15 - 19 to 60 - 64 at the end of the period.

In diagram 1 the horizontally drawn lines indicate the existing disaggregated data on deaths for infants, children aged 1,2,3,4 and for the people in the age - groups 2,3,4, ... (5 - 9, 10 - 14, 15 - 19 ....) while the vertically drawn lines in-

d_{tk} or D_{tr} \ t	1	2	3	4	5	6	7	8	9	10
d_{t0}										
d_{t1}									DG_1	
d_{t2}					DG_2					
d_{t3}										
d_{t4}										
D_{t2}					DG_3					
D_{t3}					DG_4					
D_{t4}										

Diagram 1.   Schematic representation of the method for allocating deaths to age-groups at the end of the period developed in Section I.

dicate that these data exist for each one of the 10 years of the intercensal period. The diagonally drawn lines indicate the allocation of deaths to age - groups at the end of the period. Thus the right - hand corner of diagram 1 includes the deaths of children belonging to age - group 1 (0 - 4) at the end of the period. The area between the first and second diagonal the DG_2, the area between the second and the third diagonal the DG_3 and, finally, the area between the third and the fourth diagonal the DG_4. The step - wise beginning of the first two diagonals indicates the 75 % - 25 % allocation of infant deaths.

To obtain the number of deaths of people belonging to the «residual» age - group 14 (65 +) at the end of the period we use formula (10) in Section I.

III. Allocation of Deaths to Age - groups and Estimation of Net Migration by Age and Sex for Greece for the Periods 1951 - 60 and 1961 - 70

To apply the method presented in Sections I and II we have taken the case of Greece for the period 1951 - 71. During that period three censuses were taken at the following dates : 7.4.1951, 19.3.1961 and 14.3.1971. Complete results of the first two censuses have been published by the National Statistical Service of Greece (NSSG) (1961 and 1968, respectively). Results of a 5 % sample elaboration of the 1971 census have been published by the NSSG (1973). Further results of a 25 % sample elaboration are now available in an unpublished form and, as these ought to be more accurate, they will be used in this paper along with the 1951 and 1961 complete census results.

The method developed in Sections I and II assumes that the censuses were taken on the 31st December of the last year of a decade (in our case 1950, 1960 and 1970). Given the census dates mentioned above some adjustments have to be made.

The major adjustment refers to children in the age - group 0 - 4. This is due to the definition (4) and the fact that all our formulae referring to deaths cover a ten - year period while the age - group 0 - 4 in all 3 censuses includes also the children born from the 1st January to the census date who were alive on that date. Given definition (4) the number of these children has to be subtracted from the number of children in the age - group 0 - 4 given in the census so that a number can be obtained with which the figure yielded by (4) can be compared. Further, as our formulae do not take into account the deaths occuring from the 1st January to the census date, the figure found after the subtraction of births from 1st January to census date from the census age - group 0 - 4 has to be increased by these deaths. As infant deaths are the most important, we have added 1/16 of the deaths of 0 - year olds which occured in 1961 and 1971 to the children aged 0 - 4 found in the 1961 and 1971 census, respectively, after subtraction of the children born from 1st January to census date. These adjustments are set out in table 1.

Table 1. Estimates of number of children in the age - group 0 - 4 on the 31st December 1960 and 31st December 1970

Data or Estimates	Census Year			
	1961		1971	
	Males	Females	Males	Females
Children aged 0 - 4 according to census	407198	384597	405248	382504
Births from 1st January to census date	—20649	—18665	—19370*	—18062*
Deaths of 0 - year olds from 1st January to census date	+ 205*	+ 171*	+ 132*	+ 106*
Number of children in the age-group 0 - 4 on the 31st December of the year preceding the census year	386754*	366103*	386010*	364548*

    * Estimates

    Source : NSSG.

The figures in the last row of table 1 have been used as end - of - the - period values of population in age - group 1 (P_{21}) for the intercensal periods 1951 - 60 and 1961 - 70.

The total number of deaths in the decade 1951 - 60 does not coincide with the number of deaths during the intercensal period 7.4.51 - 19.3.61 and the same applies for the decade 1961 - 70 and the intercensal period 19.3.61 - 14.3.71. These differences arise because the deaths in 1961 were by 6447 greater than in 1951 and in 1971 by 9154 greater than in 1961. If one takes a quarter of each of these figures and allocates them to the 14 age - groups, disaggregated by sex, one can see that the results would have been very similar to those obtained without taking these differences into account. We have, therefore, abstained from making any adjustment apart from the major (and unavoidable) one mentioned earlier.

The flow data on births (disaggregated by sex[1]) and on deaths (disaggregated by age[2] and sex) have been taken from the Statistical Yearbooks of Greece (1955 - 1974).

Using the data on deaths in formulae (22) - (25) and (10) we have obtained

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    1. For the years 1951 - 55 the total number of births (males and females together) was disaggregated by sex on the basis of the proportions of males and females in the births of the five - year period 1956 - 60.

    2. For the years 1951 - 54 the disaggregation of the deaths in the age - group 1 - 4 was effected using the distribution of deaths in the same group into deaths of 1,2,3 and 4 year - olds in the years 1955 and 1956 taken together.

the DG_j (j = 1,2,.....,14) for the two decades 1951 - 60 and 1961 - 70. The results are given in table 2 (M = Males, F = Females).

Table 2. Allocation of Deaths to Age - groups disaggregated by Sex for Greece in the decades 1951 - 1960 and 1961 - 1970

Age - group at the end of the period	Periods					
		1951 — 1960			1961 — 1970	
	M + F	M	F	M + F	M	F
0 — 4	33637	17691	15946	25749	14232	11517
5 — 9	44972	23792	21180	33131	18058	15073
10 — 14	10750	5937	4813	6444	3656	2788
15 — 19	5026	3066	1960	3455	2212	1243
20 — 24	5783	3513	2270	4190	2794	1396
25 — 29	7992	4595	3397	4986	3290	1696
30 — 34	9488	5221	4267	5754	3509	2245
35 — 39	9013	4875	4138	7277	4236	3041
40 — 44	9534	5127	4407	9448	5355	4093
45 — 49	13298	7454	5844	11311	6537	4774
50 — 54	18392	10738	7654	15778	9279	6499
55 — 59	24663	14716	9947	26478	16112	10366
60 — 64	30971	17965	13006	39790	24545	15245
65+	355151	169109	186042	499259	241630	257629
ALL	578670	293799	284871	693050	355445	337605

Table 2 shows that the increase in the total number of deaths in the second compared with the first decade is mainly due to the ageing of the Greek population (compare the deaths in the age - group 65 + with the sub - total of deaths in the previous 13 age - groups and see the next Section).

Using the results of table 2, the 1951, 1961 and 1971 census results and the $P_{1,-1}$ and $P_{1,0}$ for 1951 and 1961 (formed from the data on births for the periods 1951 - 60 and 1961 - 70, respectively) in formula (19) (solved for NMG_j) we obtain the estimates of Net Migration given in table 3.

Table 3. Estimates of Net Migration by Age and Sex for Greece in the decades 1951 - 60 and 1961 - 70

Age - group at the end of the period	Periods					
	1951 - 1960			1961 - 1970		
	M + F	M	F	M+F	M	F
0 — 4	446	2839	—2393	488	1163	—675
5 — 9	—9359	—3648	—5711	11129	6471	4658
10 — 14	—16872	—7491	—9381	21305	11445	9860
15 — 19	9327	12572	—3245	49725	29755	19970
20 — 24	47368	37906	9462	92525	43101	49424
25 — 29	56073	38094	17979	113451	64145	49306
30 — 34	51981	29852	22129	114912	68092	46820
35 — 39	32988	11897	21091	65587	28896	36691
40 — 44	15135	4362	10773	33854	15795	18059
45 — 49	12620	4676	7944	10057	2943	7114
50 — 54	7156	742	6414	—2309	—1717	—592
55 — 59	—3764	—207	—3557	—4082	—4884	802
60 — 64	144	1076	—932	—12242	—6394	—5848
65 +	—15285	—8610	—6675	—36914	—18827	—18087
ALL	187958	124060	63898	457486	239984	217502

Table 3 shows that :

(a) The net emigration in the second decade was nearly 2.5 times greater (and more evenly balanced between men and women) compared with that in the first decade.

(b) In both decades there was a net emigration from the age - group 15 - 19 to the age - group 45 - 49 at the end of each period. Between 67 % and 85 % of net emigration both for men and for women was in the age-groups 20 - 24, 25 - 29 and 30 - 34 at the end of each of the two decades.

(c) If we group together the people from the age - group 50 - 54 upwards we obtain, in both decades, net immigration. This immigration is almost five times larger in the second compared with the first decade.

(d) If we group together the children in the age - groups 0 - 4, 5 - 9 and 10 - 14 we obtain a net immigration total of 25785 in the first decade and a net emigration total of 32922 in the second decade. Whilst the latter figure, given the emigration of whole families to West Germany, is not implausible, the former is very difficult to explain.

The net immigration of children in the first period and the rather large figure of net immigration of people aged 50 and over in the second require a detailed investigation which can only be conducted by the Services which collect the data and carry out the general population censuses. Areas which have to investigated are :

(i) errors in the collection and/or compilation of the statistics in one or both censuses (1951 and 1961),

(ii) errors in the registration (or no registration at all) of live births and deaths and

(iii) errors in the 25 % sample elaboration of the 1971 census.

IV. The Impact of Death and Migration on the Sex and Age Structure of the Greek Population in the Periods 1951 - 60 and 1961 - 70

The results obtained in the previous Section can now be used for the estimation of the impact of death and migration on the Sex and Age structure of the Greek population in the periods 1951 - 60 and 1961 - 70 taken separately and together.

Taking first the two decades separately we define the «Death Rate» for age - group j at the end of the period as :

$$DR_j = \frac{DG_j}{P_{1,j-2}} \times 100 \tag{26}$$

i.e. the deaths of people belonging to age - group j at the end of the period as % of the population in the same age - group at the beginning of the period. The values of (26) show the percentage losses due to death of people in the age - group j - 2 (j = 1......,14) at the beginning of the period.

Similarly the «Net Migration Rate» for age - group j at the end of the period is defined as :

$$NMR_j = \frac{NMG_j}{P_{1,j-2}} \times 100 \tag{27}$$

i.e. the net migration of people belonging to age - group j at the end of the period as % of the population in the same age - group at the beginning of the period. Given the definition of Net Migration in Section I, the positive values of (27) show the percentage losses due to net emigration and the negative values the percentage gains due to net immigration of people in the age - group j - 2 (j = 1,.....,14) at the beginning of the period.

The values of (26) and (27) are shown in diagrams 2 (for the decade 1951 - 60) and 3 (for the decade 1961 - 70) for the age - groups up to but not including the «residual» age - group 65 + at the end of each period. For that age - group we

will give the values of (26) and (27) after commenting upon diagrams 2 and 3. To differentiate between males and females in these diagrams we add the letters M and F, respectively, in front of DR_j and NMR_j .
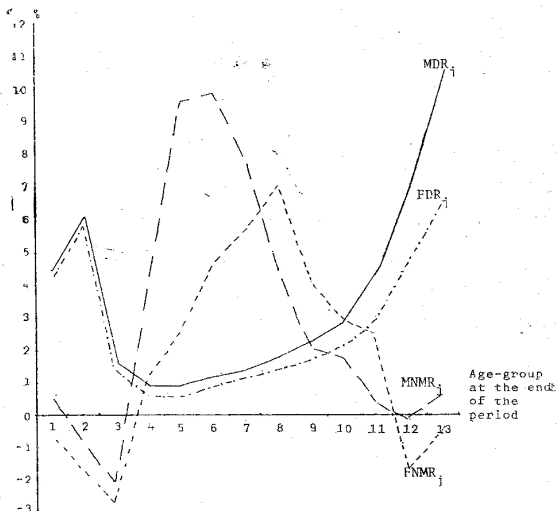

Diagram 2. Percentage losses (+) or gains (—) of Greek Population due to death and net migration during the period 1951 - 1960 by sex and in age - groups at the end of the period.

Diagrams 2 and 3 show that :

(a) In both decades the losses due to death (heavier for males than for females) were over the 3 % mark for the age - groups 0 - 4, 5 - 9 and 50 - 54 and over.

(b) In the second decade there is an overall reduction in the losses due to death for all the age - groups, except the age - group 60 - 64 for males for which there is a slight increase.

(c) The losses due to net emigration in the first decade were over 3 % from the age - group 15 - 19 to the age - group 35 - 39 for males and from 25 - 29 to
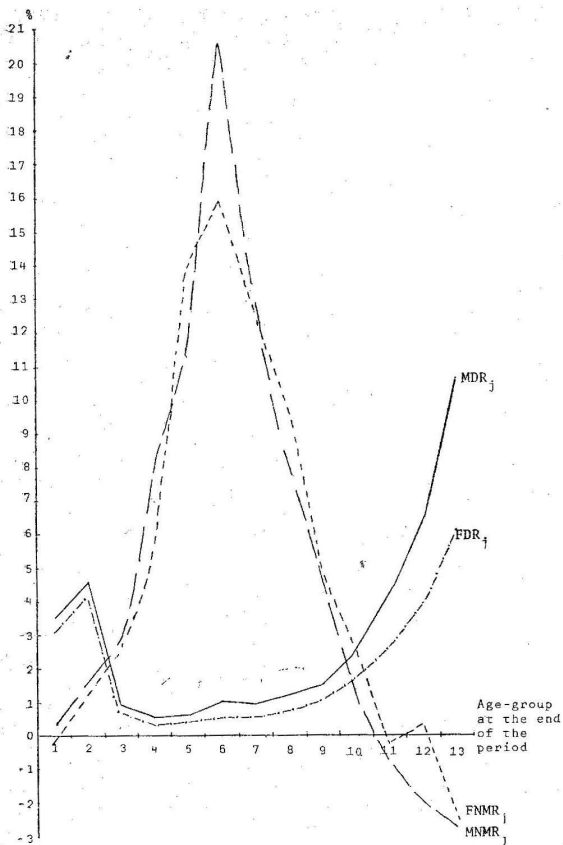
Diagram 3. Percentage losses (+) or gains (—) of Greek Population due to death and net migration during the period 1960 - 1970 by sex and in age - groups at the end of the period.

45 - 49 for females. The heaviest losses were in the age - group 25 - 29 for males (9.8 %) and the age - group 35 - 39 (7.1 %) for females.

(d) In the second decade the losses due to net emigration (both for males and for females) were greater in all the age - groups from 5 - 9 to 40 - 44 compared with the first decade. The greatest losses occured in the age - group 25 - 29 both for males (20.5 %) and for females (15.9 %). There was, in other words, a greater loss of young people due to net emigration during the second compared with the first decade.

In the residual age - group 65 + (not shown in diagrams 2 and 3) the losses due to death were slightly greater in the second (37.7 % for males and 33.1 % for females) compared with the first (37.1 % for males and 32.6 % for females) decade. For the same age - group (65 +) there was a gain in the second (2.8 % for males and 2.3 % for females) which was greater than the gain in the first (1.9 % for males and 1.2 % for females) decade which can either be attributed to net immigration or to the possible errors listed at the end of Section III[3] .

If we take as «base population» for the first decade that of the 1951 census plus the births during the period 1951 - 60 and for the second decade that of the 1961 census plus the births during the period 1961 - 70 we can calculate the overall impact of death and net migration on the Greek population during the decades 1951-60 and 1961 - 70 taken separately. This overall impact is summarised in table 4.

Table 4. Overall Losses of Greek Population (as % of the «base population») due to Death and Net Migration for the periods 1951 - 60 and 1961 — 1970

| Losses due to | 1951 — 1960 | | | 1961 — 1970 | | |
	M + F	M	F	M + F	M	F
Death	6.35	6.54	6.16	7.01	7.31	6.73
Net Migration	2.06	2.76	1.38	4.63	4.94	4.34
Death and Net Migration	8.41	9.30	7.54	11.64	12.25	11.07

Table 4 shows that during the second decade the losses due to death (mainly, as has already been pointed out, because of the ageing of the population) have increased by about 10 % (the increase was slightly greater for males compared with the females) in comparison with the first decade. The losses due to net emigration have more than doubled during the second compared with the first decade

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3. If and when the investigation referred to at the end of Section III is carried out and its results are published we will be able to say more on the origin of these "gains".

(if males and females are taken together). The increase was much greater for females (215 %) than for males (79 %). As has already been mentioned this massive increase in net emigration during the decade 1961 - 70 is mainly due to the «pull» of the West German economy.

So far we dealt with the impact of death and net migration on the Greek population in the two decennial periods 1951 - 60 and 1961 - 70 taken separately. We must give, now, a picture of the impact of these two factors on the Greek population in the two decades taken together. We can obtain such a picture for the age - groups up to and including the age - group 60 - 64 at the end of the second decade if we take the births (in 5 - year age - groups) during the period 1951 - 1970 and the 1951 census results for the age - groups 0 - 4 to 40 - 44 disaggregated by sex and construct a population pyramid showing the population found in the 1971 census and the losses due to death and net emigration between 1951 and 1970. This population pyramid is given in diagram 4 (see next page).

Diagram 4 shows that the bulk of losses of Greek population due to net emigration were between the age - groups 20 - 24 and 45 - 49 at the end of the period 1951 - 70. The age - group most heavily hit was the 30 - 34 (i.e. the age - group 20 - 24 in 1961). If we take that age - group together with the two adjacent ones (i.e. those who were 15 - 19 and 25 - 29 in 1961) we notice that two thirds of the net emigration in the age - group 20 - 49 at the end of the period (10 - 39 in 1961) came from these groups.

Diagram 4 does not show separately the effect of net migration and death for the age - groups 0 - 4 and 60 - 64 for males and females and for the age - group 55 - 59 for males. This is due to the fact that either

(i) the net emigration effect was small (males in the age - group 0 - 4 and females in the age - group 60 - 64) and the scale in which diagram 4 is drawn does not allow its separation from the death effect, or

(ii) we had a net immigration effect (small for females in the age group 0 - 4 and males in the age - group 55 - 59 but significant for males in the age - group 60 - 64) which can not be shown separately [4] in diagram 4.

Diagram 4 does not include the «residual» age - group 65 + and hence we can not see the overall impact of death and net migration in the twenty - year period 1951 - 70 on the Greek population. This impact, with an analysis in broad age - groups, is given both in absolute figures and as percentages of the «base population» of the period 1951 - 70 (i.e. the 1951 census population and the births between 1951 and 1970) in table 5.

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4. The addition of another type of shaded area in diagram 4 to show the net immigration effect would have made the population pyramid cumbersome to read.
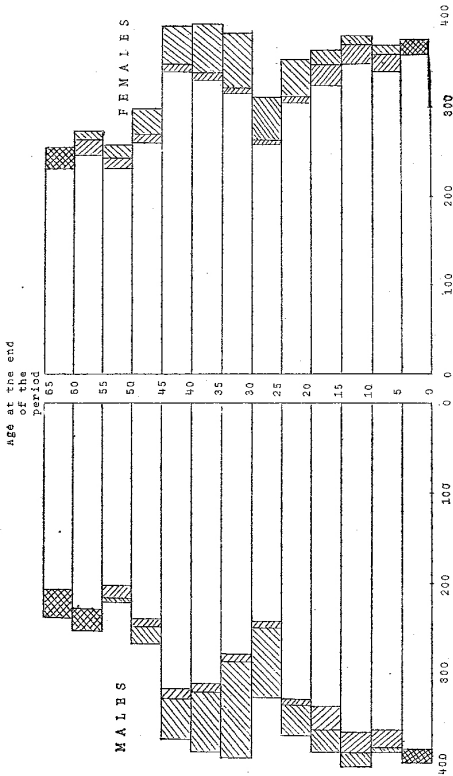
Diagram 4. Pyramid of Greek Population at the end of the period 1951-1970 showing:
Population found in the 14.3.71 census [ ] Losses due to death during the period 1951-70
Losses due to net migration during the period 1951-70
Net.losses due to death and net migration during the period 1951-70

MALES   FEMALES

Age at the end
of the
period

Population in thousands

Table 5. Losses of Greek Population due to Death and Net Migration during the period 1951 - 1970 disaggregated by sex and in broad Age - Groups at the end of the Period

Age - group at the end of the period	Net Migration			Deaths		
	M + F	M	F	M + F	M	F
	A. Absolute Figures					
0 — 19	73734	48025	25709	147388	79641	67747
20 — 49	611251	345802	265449	91018	52928	38090
50 +	—39541	—29783	—9758	1033314	516675	516639
ALL	645444	364044	281400	1271720	649244	622476
	B. As Percentages of the 1951-70 Births and the 1951 census results					
0 — 19	2.40	3.02	1.73	4.79	5.01	4.56
20 — 49	14.34	16.19	12.48	2.13	2.48	1.79
50 +	—1.20	—1.91	—0.56	31.21	33.21	29.43
ALL	6.06	6.89	5.24	11.94	12.30	11.60

Table 5 shows that through net emigration in the period 1951 - 1970 the Greek population lost almost 15 % of the people who were in the age-group 10 - 39 in 1961 and 2.4 % of the people born from 1951 to 1970. On the other hand, through net immigration the Greek population gained (see, though, footnote 3) 1.2 % of the people who were over 40 in 1961. The overall loss of Greek population in the period 1951 - 70 due to net emigration was half that due to death, a toll which was, perhaps, heavier than that of the Second World War and the Civil War which followed it in the decade 1940 - 1949.

V. Immigration Disaggregated by Sex and in Age - Groups

Whilst there are published data on deaths for Greece from 1951 onwards for infants, children aged 1,2,3, and 4 years (see also footnote 2) and in age - groups starting from the age - group 5 - 9, the data on permanent emigration are available only from 1955 onwards and in age - groups starting from the age - group 0 - 4.

We can, therefore, apply (20) only for the second intercensal period [5] 1961 - 70.

Making the assumption (see also Section II) that emigration is affecting equally the people in a specific age - group (e.g. the people aged 20, 21, 22, 33 and 24 in the age - group 20 - 24) and is equally spread throughout the year we have, in order to apply (20), to give first the formulae on which the allocation of emigration to age - groups at the end of the period is based.

On the basis of the assumptions just mentioned (and working as in section II), for age - group 1 (0 - 4) at the end of the period we allocate in year 6 10 % of the recorded emigration in that year of children in that age - group. In year 7 we allocate 30 % and so on up to year 10. Hence the formula for allocating emigration to the first age - group at the end of the period is :

$$EG_1 = \sum_{t=6}^{10} \{ 0.10 + (t - 6) \ 0.20 \} \ E_{t1} \tag{28}$$

For the age - group 5 - 9 at the end of the period we follow the logic on which (28) is based up and including year 5. From year 6 onwards we note that gradually the children born in the first five years of the decade move to age - group 5 - 9 at the end of the period. Hence in year 6 we allocate to that age - group 90 % of E_{61} and 10 % of E_{63}. In year 7 we allocate 70 % of E_{71} and 30 % of E_{72} and so on. The formula, therefore, for allocating emigration to the second age - group at the end of the period is :

$$EG_2 = \sum_{t=1}^{5} \{ 0.10 + (t - 1) 0.20 \} \ E_{t1} + \sum_{t=6}^{10} [\{ 0.10 + (10 - t) \ 0.20 \} \ E_{t1} +$$

$$+ \{ 0.10 + (t - 6) 0.20 \} \ E_{t2}] \tag{29}$$

From the age - group 3 (10 - 14) to the age - group 13 (60 - 64) at the end of the period the logic is exactly the same as for formula (25) in section II, i.e.

$$EG_r = \sum_{t=1}^{5} [\{ 0.10 + (5 - t) \ 0.20 \} \ E_{t,r-2} + \{ 0.10 + (t - 1) 0.20) \ E_{t,r-1}] +$$

$$+ \sum_{t=6}^{10} [\{ 0.10 + (10 - t) \ 0.20 \} \ E_{t,r-1} + \{ 0.10 + (t - 6) \ 0.20 \} \ E_{t,r}]$$

$$r = 3, 4, \ldots, 13 \tag{30}$$

If we were to represent this method diagrammatically we would have drawn a diagram similar to Diagram 1 but without the step - wise beginning of the first

two diagonals. For the «residual» age - group 65 + at the end of the period we apply (14).

The data used for the application of formulae (28), (29), (30) and (14) to the case of Greece for the period 1961 - 70 were those published by the NSSG in the Statistical Yearbooks on permanent [6] emigration of Greek citizens disaggregated by sex and in age - groups.

After obtaining the emigration for the 14 age - groups we use the results in conjunction with the results on net migration [7] given in table 3 in formula (20) solved for IG_j , $j = 1,2,\ldots\ldots,13,14$. The results obtained both for emigration and for immigration by age and sex are given in table 6.

Table 6. Emigration and Immigration by Age and Sex for Greece in the period 1961 - 70

Age - group at the end of the period	Emigration			Immigration		
	M + F	M	F	M + F	M	F
0 — 4	9597	5089	4508	9109	3926	5183
5 — 9	22670	12029	10641	11541	5558	5983
10 — 14	24656	12783	11873	3351	1338	2013
15 — 19	35749	15930	19819	—13976	—13825	—151
20 — 24	93922	45504	48418	1397	2403	—1006
25 — 29	141821	77351	64470	28370	13206	15164
30 — 34	165523	99789	65734	50611	31697	18914
35 — 39	143566	93935	49631	77979	65039	12940
40 — 44	91720	61618	30102	57866	45823	12043
45 — 49	44116	29254	14862	34059	26311	7748
50 — 54	19555	12170	7385	21864	13887	7977
55 — 59	12985	6669	6316	17067	11553	5514
60 — 64	9511	4246	5265	21753	10640	11113
65 +	15033	6431	8602	51947	25258	26689
ALL	830424	482798	347626	372920	242814	130124

Whilst according to the definitions given in Section I

$$IG_j \geqslant 0$$

6. The definition of "permanent" emigration given in the Statistical Yearbooks of Greece is as follows : "Greek citizens, permanently residing in Greece, who go abroad to settle there for a period exceeding one year".

7. Net migration figures in table 3 are assumed to refer only to Greek citizens. If this assumption is removed the results given in table 6 have to be modified. The first step for this modification is the disaggregation of the "balancing equation" into two parts : one referring to natives and the other to foreigners residing in a country (see the paper by the author (1974).

table 6 shows that $IG_i < 0$ for males and females in the age - group 15 - 19 and for females in the age - group 20 - 24 at the end of the period. These negative immigration figures (as well as the low immigration figure for males in the age - group 20 - 24) may be partly due to the errors mentioned at the end of Section II in connection with the age - groups 5 - 9 and 10 - 14 in table 3.

Another source of error (to which the negative or low immigration figures in table 6 may be attributed) is the misreporting (on the part of the emigrants, intentionally or unintentionally) the type of emigration. This means that part of what is recorded in the Greek emigration statistics as «temporary» is in fact permanent emigration.

Apart from the errors mentioned at the end of Section II and the misreporting of the type of emigration, the negative or low immigration figures in table 6 may be due to under - recording of Greek emigration. Evidence on this can be obtained from West German sources [8]. If we take the period 1961 - 1971 (i.e. the decennial period nearest to the intercensal period 1961 - 70) for which data on Greek emigration to West Germany exist both from West German [9] and Greek sources [10], we obtain the following summary picture :

Table 7. Greek Emigration to Germany 1962 - 1971

Sex	Emigration to West and East Germany according to Greek sources			Inflow of Greeks to West Germany according to West German sources
	Permanent	Temporary	Permanent + Temporary	
M	299251	42719	341970	386994
F	209066	734	209800	272934
M + F	508770	43453	551770	659928

Sources : NSSG (1955 - 1974).
　　　　　Statistisches Bundesamt (1963 - 1974).

Table 7 shows that part of the negative immigration figure for males may be due to reporting permanent migration as temporary. The table also shows

8. From the data on emigration by country of destination published by the NSSG one can see that West Germany was the main receiving country of Greek permanent emigrants during the period under consideration.

9. We have to note here that the definition of emigration in Greek sources does not coincide with that of the inflow in the West German sources. Moreover these latter sources are not error - free (see the paper by the author (1974).

10. The Greek sources on both permanent and temporary emigration do not separate West from East Germany.

that another part of the negative or low immigration figures in table 6 is due to under - recording of emigration which is greater for females than for males.

If we accept the estimates of net migration in table 3 as approximately correct, the under - recording of emigration implies that the figures given in table 6 are underestimating immigration. That this is, in fact, the case is shown by taking the West German data on the outflow of Greeks from West Germany to Greece for the period 1962 - 1971. According to these data the outflow of Greek men was 236880 and of Greek women 137278 i.e. figures similar to those of table 6 which, though, refer to immigration not only from West Germany but from all other countries.

This is, perphaps, an appropriate place to point out that the under - recording detected in Greek emigration statistics appears, also, in the immigration statistics which are published by the NSSG from 1968 onwards. According to these statistics the total immigration from all countries for the period 1968 - 1973 was 134195, whilst according to the Statistisches Bundesamt the outflow of Greeks only from West Germany to Greece was 220688.

Bearing in mind what has been said about the under - recording of emigration and the under - estimation of immigration we can proceed to analyse the data of table 6 further.

We have noted above and in another paper (1973) the high proportion of women in Greek emigration after 1961. We can investigate this more systematically, as we have done in our paper for the aggregate flows of migrants from and to West Germany from six sending countries (1975), by defining (for emigration as well as for immigration) as «Sex Ratio» the ratio of females over males i.e. for emigration the «Sex Ratio» for age - group j is defined as :

$$SER_j = \frac{FEG_j}{MEG_j} \qquad (31)$$

and for immigration :

$$SIR_j = \frac{FIG_j}{MIG_j} \qquad (32)$$

where the letter F in the numerator of (31) and (32) denotes females and the letter M in the denominator of the same expressions males. Definitions analogous to (31) and (32) hold for the aggregate emigration and immigration, respectively.

Another statistic used in the paper mentioned above (1975) was that of the «Turnover Ratio», i.e. the ratio of Immigration over Emigration. The «Turnover Ratio» for age - group j at the end of the period is defined for males as :

$$TMR_j = \frac{MIG_j}{MEG_j} \qquad (33)$$

and for females as

$$TFR_j = \frac{FIG_j}{FEG_j} \qquad (34)$$

Definitions analogous to (33) and (34) hold for the aggregate immigration and emigration of males and females, respectively. Given the volatility of migrant workers in West Germany and the high proportion of Greek emigrants who were going to work in that country during the decade 1961 - 70, the «Turnover Ratio» can be interpreted (roughly) as the proportion of emigrants returning home. This interpretation led us to calculate Turnover (and Sex) ratios only for the age - groups 6 to 10 (i.e. from the age - group 25 - 29 to the age-group 45 - 49) at the end of the period 1961 - 70 i.e. the age - groups from which migrant workers were recruited. These ratios are given in table 8. In the same table we give, for comparison pur- poses, the Sex and Turnover ratios for total Emigration and Immigration derived from the last row of table 6 as well as the same ratios derived from the total Inflow and Outflow of Greek Men and Women for the decennial period 1962 - 1971 in and out of West Germany[11].

Table 8. Sex Ratios and Turnover Ratios of Greek Migrants for selected Age - groups at the end of the period 1961 - 1970

Age - group at the end of the period	Sex Ratios		Turnover Ratios	
	Emigration	Immigration	Males	Females
25 — 29	0.833	1.148	0.171	0.235
30 — 34	0.659	0.597	0.318	0.288
35 — 39	0.528	0.199	0.692	0.261
40 — 44	0.489	0.263	0.744	0.400
45 — 49	0.508	0.294	0.899	0.521
ALL data from (a) table 6	0.720	0.536	0.503	0.374
(b) West German sources 1962 — 1971	0.705	0.580	0.612	0.503

The last two rows of table 8 show that there is no great difference in the Sex

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11. Data obtained from Statistisches Bundesamt (1963 - 1974).

Ratios derived from Greek and West German sources. This is natural given the importance of West Germany as a country of employment of Greek male and female migrant workers. As the Sex Ratios for immigration is lower than the same ratio for emigration, more women (proportionately) stay abroad than men. This is confirmed by looking at the Turnover Ratios of males and females.

The Turnover Ratios derived from West German sources are higher than those derived from Greek sources. Again this is to be expected as more economically active Greek emigrants go to West Germany than to other countries and these, after staying and working in West Germany for some years, tend to return to Greece.

What has been said for Sex and Turnover Ratios for Migrants in all age-groups applies also to the individual age-groups given in table 8 except the first one. This means that young women tend to return, proportionately, more to Greece than young men.

The Sex and Turnover Ratios are similar in the age-group 30-34. This may be due to the fact (see Bundesanstalt fuer Arbeit, 1973) that young couples went to work to West Germany and returned to Greece together.

The Turnover Ratios are greater for the last three age-groups listed in table, 8. This may be an indication that difficulties in adaptation to a foreign country force the older emigrants to return home more (proportionately) than the younger ones.

Conclusion

It was shown in this paper that, by allocating deaths to age-groups at the end of the period and disaggregating the «balancing equation», we can derive estimates for net migration during an intercensal period disaggregated by age and sex and thus estimate the impact of death and migration on the population of a country. Further, by allocating emigration to age-groups (in a way similar to that for deaths) estimates on immigration, also disaggregated by age and sex, can be derived for the same period. Finally useful statistics on the characteristics of the migrants can be derived from the emigration and immigration estimates.

The main findings from the application of this method to the case of Greece for the period 1951-70 were the following :

1. The ageing of the Greek population resulted in an increase in the absolute number of deaths during the decade 1961-70 compared with the decade 1951-70. Moreover the impact of death in the age-group 60 + increased in the second compared with the first decade while the opposite was true for all the other age-groups.

2. The «pull» of the German economy resulted in a net emigration during the second decade which was 2.5 times greater than that of the first. In both decades the net emigration was concentrated in the age-group 15-49 at the end of the period. The heaviest losses of Greek population due to net emigration were

in the age - group 25 - 29 at the end of each decade for males, in the age - group 35 - 39 at the end of the decade 1951 - 60 and the age - group 25 - 29 at the end of the decade 1961 - 70 for females.

3. The overall loss of Greek population during the two decades 1951 - 70 due to net emigration was half that due to death. The heaviest losses due to net emigration were in the age - group 10 - 39 in 1961 (20 - 49 at the end of the period).

4. The return flows of Greek migrants during the decade 1961 - 70 were about 40 % of the outflows but this may be an under - estimate. The returning migrants were older than the emigrants.

The method for allocating deaths to age - groups can be improved by :

(i) using for all age - groups, after the first, more detailed formulae than the ones developed in section II, if data on deaths are published not by age - groups but for individual ages, and

(ii) using for all age - groups, including the first, even more detailed formulae if data on deaths (by sex and for individual ages) become available on a monthly or quarterly basis.

Similarly the method (and the accuracy of the results) can be improved as far as emigration and immigration estimates are concerned if the data on emigration are published not for age - groups but for individual ages and become available monthly or quarterly. In such a case modifications have to be made in the formulae for allocating emigration to age - groups.

The method developed in this paper, apart from the intrinsic interest which the results obtained present, can be seen as a method of checking the accuracy of (complete or sample elaboration) census results and/or flow data (births, deaths and emigration), of locating specific deficiencies and trying to correct them. The ways suggested for the improvement of the method, on the other hand, point to areas in which the collection of data can be directed.

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