WORKING PAPER

THE DEMOGRAPHIC DISCONTINUITY
OF THE 1940s

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Abstract

The expansion of world population in the 20th century did not take place as a smooth acceleration, but showed sudden changes in the demographic parameters on at least two occasions. The main one was in the 1940s, when the amount of increase between cohorts rose three fold within as little as five years; an earlier similar increase took place about 1920. Earlier than these, a rise about the year 1900 is suggested. All of this is inferred from censuses taken since 1950. Nothing beyond data on age distributions at five year intervals from 1950 onwards is needed to estimate intercohort increases with small and measurable error. A check on the process is to proceed backwards, and apply the calculated average intercohort increases to reconstruct the original age distributions. Intercohort increase is a net amount that includes some decrease of mortality, especially infant mortality, and some increase of fertility.

The technique used provides new information concerning the onset of the so-called population explosion. For the world as a whole that onset was especially sudden because of the coincidence of the postwar baby boom in developed countries and the fall in mortality due to inoculation and antibiotics in the less developed. The measure of discontinuity being linear and additive, it can be decomposed precisely by continents and countries. Besides the MDCs, the mid 1940s showed a leap forward in Malaysia, Egypt and Turkey; the corresponding leap took place about five years later in Pakistan, Vietnam and Indonesia. China accelerated over a longer period, something like 10 years rather than 5. The acceleration occurred also in Latin America but there it started earlier and continued longer and more slowly. Tropical Africa shows little discontinuity in the rate of change, but very rapid growth throughout, perhaps due to shortcomings of the data.

Acknowledgements

I am grateful to Douglas Wolf, Wolfgang Lutz, and Shiro Horiuchi for correcting errors on earlier drafts of this paper, to Susan Stock for skilled typing, and to the Ford Foundation and IIASA for material help. Gary Sick asked some of the questions to which this work seeks answers.

The Demographic Discontinuity of the 1940s

Nathan Keyfitz

A remarkable change in the world's demographic parameters took place in the 1940s. Its nature and magnitude can be appreciated from TABLE 1 and FIGURE 1, showing age distribution from 1950 at five-year intervals as estimated by the United Nations (1986). One can see following the bottom curve that represents 1950, that the difference between the number of persons under 5 and the number 5-9 was greater than the difference between the 5-9 and the 10-14, and very much greater than the difference between the 10-14 and 15-19. Looked at the other way and comparing the bottom curve for 1950, with the second curve for 1955, the 5-9 increase much more between 1950 and 1955 than do the 10-14. The differences follow through the successive years, working their way diagonally down the table.
Two sharp bends appear in the curves of FIGURE 1 corresponding to the persons 5-9 and 30-34 in 1950, and so referring to the cohorts of 1940-45 and 1915-20. The technique developed below is designed to measure and account for the radical changes indicated by these bends, and especially that of the 1940s that initiated the famous population explosion.

AGE BY AGE DIFFERENCES

One way of bringing out the essential features of the curves of FIGURE 1 is by first differences by age, as in TABLE 2. Thus from TABLE 1, taking for 1950 the 0-4 of 341 million and subtracting the 5-9 of 270 million gives the 71 million as shown at the top left of TABLE 2.

But we are more interested in following cohorts than in age distributions as such, and to do that we reassemble the same numbers according to cohort. TABLE 3 provides a window into the 30 × 16 matrix, in which the full set of estimates and projections, applying to the years 1950 to 2025, as provided by the United Nations, are reassembled into columns corresponding to cohorts. It was calculated by simple offsetting of each successive row of TABLE 1 one further column to the left. Each column now contains a survivorship table for identical individuals. The columns differ from one another insofar as mortality changed from one time to the next, and insofar as births were different in different five-year periods. The

TABLE 1. World Population by age, 1950 to 1980, estimates by the United Nations (1986) (millions of persons).

Age	1950	1955	1960	1965	1970	1975	1980
0-4	341	400	429	478	522	544	541
5-9	270	317	376	407	459	503	526
10-14	258	284	312	370	403	455	499
15-19	239	253	259	307	365	400	451
20-24	220	233	247	254	301	360	394
25-29	195	214	227	242	249	296	354
30-34	165	189	208	222	237	245	292
35-39	159	158	183	203	216	232	241
40-44	145	152	152	177	198	211	228
45-49	126	137	145	145	170	192	204
50-54	106	117	128	137	137	162	184
55-59	89	95	107	119	129	129	153
60-64	73	79	84	95	108	118	118
65-69	55	61	66	71	83	94	103
70-74	38	43	48	53	56	66	77
75-79	22	25	28	32	36	39	48
80-84	13	16	18	22	26	31	36
TOTAL	2516	2751	3019	3334	3693	4076	4450

TABLE 2. First differences by age from TABLE 1 showing estimates and projections from the United Nations (1986); world as a whole (millions of persons).

Age	1950	1955	1960	1965	1970	1975	1980
0-4	71	82	53	71	63	40	14
5-9	13	53	64	37	56	48	27
10-14	18	12	53	63	38	56	48
15-19	19	19	12	53	64	40	57
20-24	26	19	20	12	53	64	40
25-29	30	25	19	20	12	51	63
30-34	5	30	26	19	21	13	51
35-39	15	6	31	26	18	22	13
40-44	19	15	7	32	28	19	24
45-49	20	20	17	8	33	29	20
50-54	17	22	21	18	9	34	31
55-59	16	17	23	24	21	11	35
60-64	18	18	18	25	25	24	15
65-69	17	18	19	18	27	28	26
70-74	16	18	19	20	20	26	28

column under the heading 1950, 341, 317, 312, ..., is a kind of decrement table for the 1945-50 generation, and will have a central place in the reconstruction of TABLE 1 that will test the model to be developed.

TABLE 3. Data of TABLE 1 arranged by cohorts; window showing cohorts born 1925-30 to 1955-60; estimates and projections from United Nations (1986) (millions of persons).

Age	Cohort born in five year period ending with the year 1930	1935	1940	1945	1950	1955	1960
0-4	-	-	-	-	341	400	429
5-9	-	-	-	270	317	376	407
10-14	-	-	258	264	312	370	403
15-19	-	239	253	259	307	365	400
20-24	220	233	247	254	301	360	394
25-29	214	227	242	249	296	354	389
30-34	208	222	237	245	292	349	384
35-39	203	216	232	241	287	344	379
40-44	198	211	228	236	282	339	373
45-49	192	204	222	230	276	332	366
50-54	184	197	215	223	268	323	357
55-55	175	187	205	213	257	311	344
60-64	162	174	191	199	241	293	325
65-69	144	156	172	180	220	267	297
70-74	121	131	146	154	189	231	-

Now let us take the differences given in TABLE 2 and similarly rearrange these along cohort lines. That is done in TABLE 4.

If we disregard the first row, different from the others because it includes the effect of infant mortality, and the rows after about age 55 when mortality again starts to rise, there is a certain uniformity within each column in the remainder of the table. Thus for the cohort born in the five years prior to 1950, its increase from age 5-9 to 10-14 is 53 million (checked from TABLE 1 by 317 - 264 = 53), and the further numbers down the column are 53, 53, 53, 53, 51, etc. Note that these are not differences of successive ages of given cohorts; rather they are measures of the growth from one cohort to the next as inferred from the period difference at any one moment between successive age groups. At least three facts appear.

1) If for the moment we disregard mortality (as well as migration and enumeration error), the excess of the 1945-50 cohort over the 1940-45 cohort is given by the column under 1950, and it shows for the first few entries after the first about 53 million. The column for the just preceding period, to the left of this one, shows only 12 or 13 million persons for its first few entries. In short within one five year interval there was a fourfold increase in the rate of cohort-to-cohort growth as measured on this preliminary and crude approach.

TABLE 4. First differences of ages in TABLE 2 rearranged to show columns for cohorts; world as a whole. Window showing 1910-15 to 1955-60 with each column giving increase over previous five-year period (millions of persons).

Age	Cohort born in five year period ending with the year 1915	1920	1925	1930	1935	1940	1945	1950	1955	1960
0-4	-	-	-	-	-	-	-	71	82	53
5-9	-	-	-	-	-	-	13	53	64	37
10-14	-	-	-	-	-	18	12	53	63	38
15-19	-	-	-	-	19	19	12	53	64	40
20-24	-	-	-	26	19	20	12	53	64	40
25-29	-	-	30	25	19	20	12	51	63	39
30-34	-	5	30	26	19	21	13	51	62	39
35-39	15	6	31	26	18	22	13	51	63	40
40-44	15	7	32	28	19	24	14	52	63	41
45-49	17	8	33	29	20	25	15	53	64	43
50-54	18	9	34	31	22	28	18	55	66	46
55-59	21	11	35	34	25	31	22	57	69	51
60-64	24	15	37	37	29	35	27	61	73	57
65-69	26	20	39	40	35	41	34	65	79	67
70-74	28	23	40	43	39	46	41	69	83	-

2) About the same thing can be said for the cohort born in the five years before 1920. Apparently some dramatic change took place around 1925, corresponding—though at a lower level—to what occurred in the 1950.

3) The enormous impetus given in the late 1940s was followed by an even greater increase in the early 1950s, but is gradually wearing itself out. We must be careful in drawing conclusions on cohorts much after 1970; the table includes both estimates of what happened in the past and projections for the future, and insofar as we rely on the latter we are merely reading out the assumptions put in by the United Nations' authors.

The differences of TABLE 4 in effect include the whole of mortality along with the cohort-to-cohort differences. Can we obtain clearer results by taking the differences in the other direction? Instead of a cohort arrangement of the age to age differences, suppose we take a cohort arrangement of the period-to-period increases at given ages. In TABLE 1 for example, the persons under 5 years of age, are 400 million in 1955 and 341 million in 1950, so the difference is 59 million, as shown under 1955 in TABLE 5. That is a different way of measuring cohort-to-cohort increases, and we see that it produces even more consistent results (TABLE 5). It is this uniformity of the numbers in each column of TABLE 5, in part deriving from the rapidly improving mortality of the postwar years, that is the basis of the present unconventional approach.

TABLE 5. Increase at given age group over preceding five years, arranged in cohort form; world as a whole (millions of persons).

	Cohort born in five year period ending with the year									
Age	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965
0-4	-	-	-	-	-	-	-	58	30	49
5-9	-	-	-	-	-	-	47	59	31	52
10-14	-	-	-	-	-	7	48	58	33	52
15-19	-	-	-	-	13	7	48	58	35	52
20-24	-	-	-	13	14	7	47	58	34	52
25-29	-	-	19	13	15	7	47	58	34	52
30-34	-	24	20	13	15	9	46	58	34	52
35-39	-1	24	20	13	17	8	46	57	34	52
40-44	0	25	21	13	18	8	46	57	34	52
45-49	0	25	22	12	18	8	46	56	34	52
50-54	0	25	22	12	18	8	45	56	34	51
55-59	0	24	22	12	18	8	44	54	33	50
60-64	1	23	21	12	17	8	42	52	32	48
65-69	1	21	19	11	16	8	39	48	30	-
70-74	2	19	17	10	15	8	35	42	-	-

DIFFERENCES BETWEEN POINTS OF TIME AT GIVEN AGE

The five-year increases of the given age groups in TABLE 5, arranged in cohort form, are even more strikingly uniform down columns (i.e. in measuring the increase from one cohort to the next) than the numbers of TABLE 4 and that makes the contrast between columns more impressive. Under the column headed 1950 we have various more or less independent estimates of the amount by which the 1945-50 cohort exceeds the 1940-45 cohort, as measured by census type information from the several ages. This figure, 47 or 48 million, is itself topped by the next column, that shows 58 or 59 million.

All of the above tables showing cohorts are windows in a diamond-shaped configuration that is 29 columns wide, with the window opening on to the middle part of the diamond. There is not much interest in the part that was omitted on the right hand side, since it consists largely in projected figures, but the triangle omitted on the left could tell us about what was happening prior to 1915. In fact (TABLE 6) it even gives indications as far back as 1880-85. What it tells is that the 19th century rate of population increase was remarkably slow, and at the new century there

FIGURE 1. **Age distribution, world as a whole, based on estimates and projections provided by the United Nations (1986), millions of persons.**

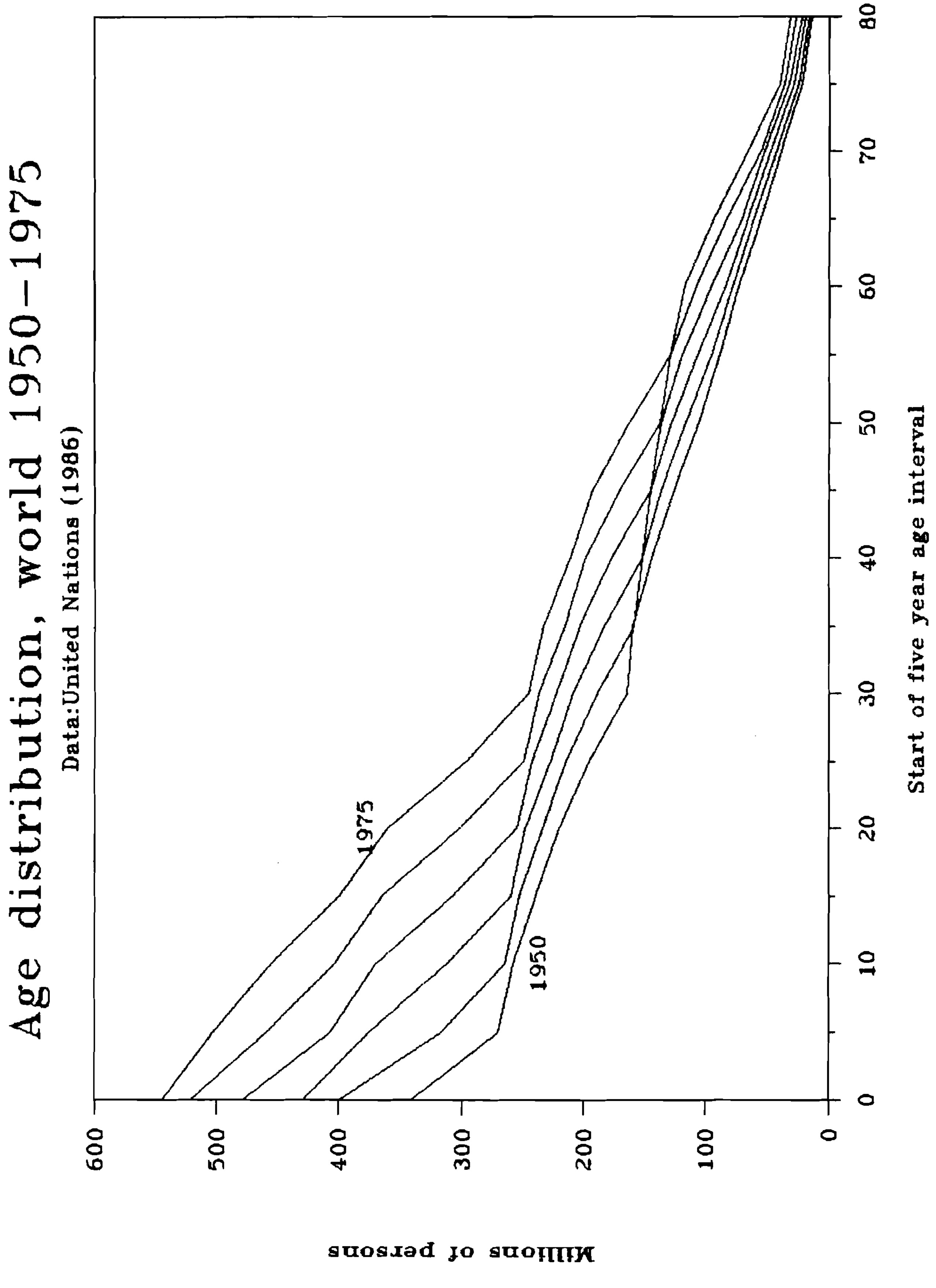
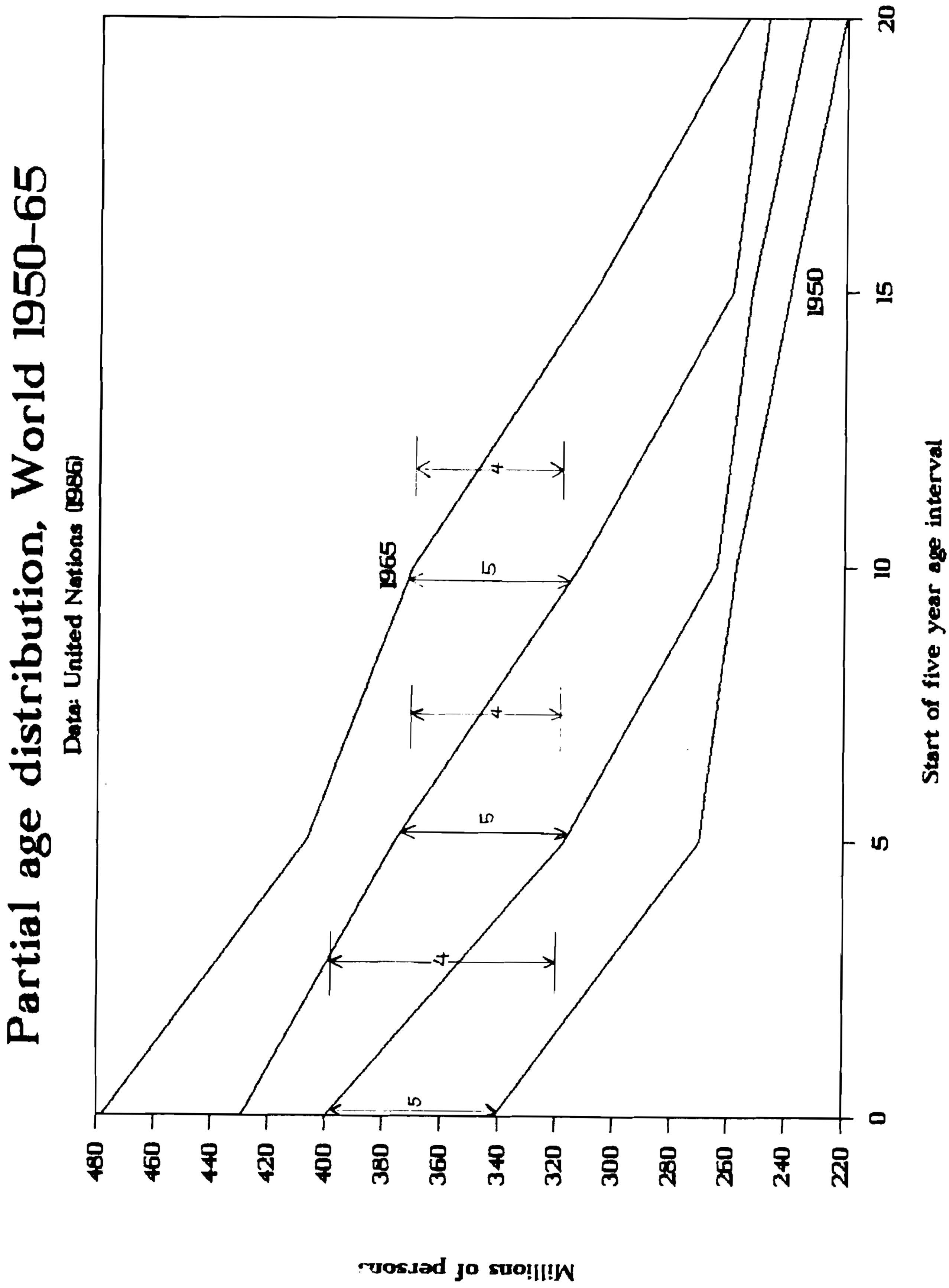


FIGURE 1A. Enlargement of part of FIGURE 1. The intervals marked 4 are the age differences of Table 4; those marked 5 are the time differences of Table 5.



was a jump to double the previous rate of increase. With the exception of the 1915-20 cohort that double level continued to 1920, when there was again a sharp rise, that approximately continued, with a falling back during World War II. And then came the big jump between 1940-45 and 1945-50 that is a main interest of this paper, shown in TABLE 5.

When world population growth is seen as a series of period totals it is a relatively smooth curve, until the 1970s rising with more than exponential steepness. When cohort differences are taken the acceleration appears as steps, clearly measurable from age distributions derived from censuses in 1950 and subsequently. There were distinct jumps about 1900, about 1920, and about 1945, each one something like a doubling of the rate of growth from the previous step.

TABLE 6. Left corner of diamond-shaped figure of which TABLE 5 gives middle; world as a whole (millions of persons).

	Cohort born in five year period ending with							
Age	1885	1890	1895	1900	1905	1910	1915	1920
30-35	-	-	-	-	-	-	-	-
35-39	-	-	-	-	-	-	-	-1
40-44	-	-	-	-	-	-	7	0
45-49	-	-	-	-	-	11	8	0
50-54	-	-	-	-	11	12	9	0
55-59	-	-	-	6	12	12	10	0
60-64	-	-	5	5	12	12	10	1
65-69	-	5	5	5	12	11	9	1
70-74	5	5	5	3	10	11	8	2
75-79	3	4	4	3	9	8	6	2

From the viewpoint of FIGURES 1 the differences shown in TABLE 4 are each taken along a single curve, and the columns are what appear from successive curves along a (more or less because of mortality) horizontal section. The differences of Tables 5 and 6, on the other hand, are also taken along horizontal sections, but they are the height of each of the curves of FIGURE 1 above the curve beneath. The distinction is shown in FIGURE 1A, which is an enlargement of FIGURE 1.

The extraordinary uniformity of the numbers in each column of Tables 5 and 6 is crucial to the present analysis of age distributions, our use of these results, and in TABLE 7 this uniformity is measured by standard deviation and range and then put to use in the reconstruction of TABLE 1.

AVERAGE COHORT INCREASE

Tables 5 and 6 show the increase in given age groups from one point of time to a point of time five years later; each of their numbers can be interpreted as the increase from one five-year cohort to the next. The apparent homogeneity of the numbers within columns, plus this interpretation that makes them out to represent the same entity, tempts one to average them in order to secure the best available estimate of the increase from one cohort to the next, overlooking (better assimilating) mortality changes. This we do for the world in TABLE 7. We only go as far as the 70-74 age group, deleting the last row in order to exclude the somewhat ragged numbers that the oldest ages would show. Thus the fourth figure, for 1900, in TABLE 7, the increase from the 1880-85 to the 1885-90 cohort, is the total of the third column of TABLE 6, i.e. 6 + 5 + 5 + 3 = 19, and it is here divided by 4, which is the number of rows of TABLE under 1900 and above 75-79. The totals and averages are rounded independently, so the numbers of Tables 5 and 6 do not always quite add to column 2 of Table 7.

This convenient uniformity of absolute differences depends on the fact that mortality improvement was steady and large during the post-war period. Our constant intercohort differences, virtually invariant with respect to the date at which they are measured, depend on the fact that mortality improvement over time just about offset the increasing mortality with age, at least over considerable intervals of age.

The the third column of TABLE 7 is the payoff on our labors. To emphasize its message,

1) There was a level and low rate of intercohort increase in the 19th century, as far back as we can deduce from the age data of 1950 onwards;
2) A first doubling occurred with the increase of the cohort born in 1900-05;
3) A further rise, to a level twice as high as that of 1900-15, occurred with the cohort of 1920-25, after a cohort that showed no increase at all, presumably as a result of World War I;
4) Again a doubling to an unprecedented level with the cohort of 1945-50;
5) A somewhat irregular tendency to decline since 1955;
6) The decline at the very end of the table is mostly an assumption of the projection, and this applies even more to the cohorts from 1975 onwards that are omitted from the table.

TABLE 7. Averaging the amount of increase between successive five-year cohorts; world as a whole (millions of persons). Totals and averages refer to the 5 years prior to the date given, and they show the increase over the cohort born five years before that.

Cohort born in 5 years preceding	Total for available cohorts (1)	No. of available cohorts (2)	Average (3)= (1)/(2)	Standard deviation within cohort	From Tables 5 and 6 min	max
1885	5	1	5	0	5	5
1890	10	2	5	0.343	5	5
1895	16	3	5	0.178	5	5
1900	19	4	5	1.060	3	6
1905	56	5	11	0.636	10	12
1910	69	6	11	0.581	11	12
1915	60	7	9	0.817	7	10
1920	2	8	0	0.808	-1	2
1925	210	9	23	2.036	19	25
1930	203	10	20	1.519	17	22
1935	135	11	12	0.857	10	13
1940	193	12	16	1.543	13	18
1945	101	13	8	0.687	7	9
1950	626	14	45	3.643	35	48
1955	830	15	55	4.560	42	59
1960	462	14	33	1.718	30	35
1965	668	13	51	1.339	48	52
1970	528	12	44	0.448	43	45

It bears repeating that each of the numbers in TABLE 7 except the first is the average of more than one measure of the increase of successive cohorts. These measures are in general in close agreement, as summarized in the last columns of TABLE 7 that show the standard deviation of the several measures that are averaged, as well as the smallest and the largest of these. In the majority of instances the standard deviation is much less than 10 per cent of the mean. The calculated standard deviations confirm the impression given by the appearance of Tables 5 and 6 that the increase of the several ages over time is consistently estimated for any one cohort, and hence the differences between cohorts are to be taken seriously.

The point is emphasized by FIGURE 2 and FIGURE 2A, that show the middle value, along with the lowest and highest values, for each of the estimates of inter-cohort increase.

FIGURE 2. Intercohort increases 1895-1975, as calculated from population age distributions 1950-2020 estimated and projected by the United Nations (1986), world as a whole, millions of persons.

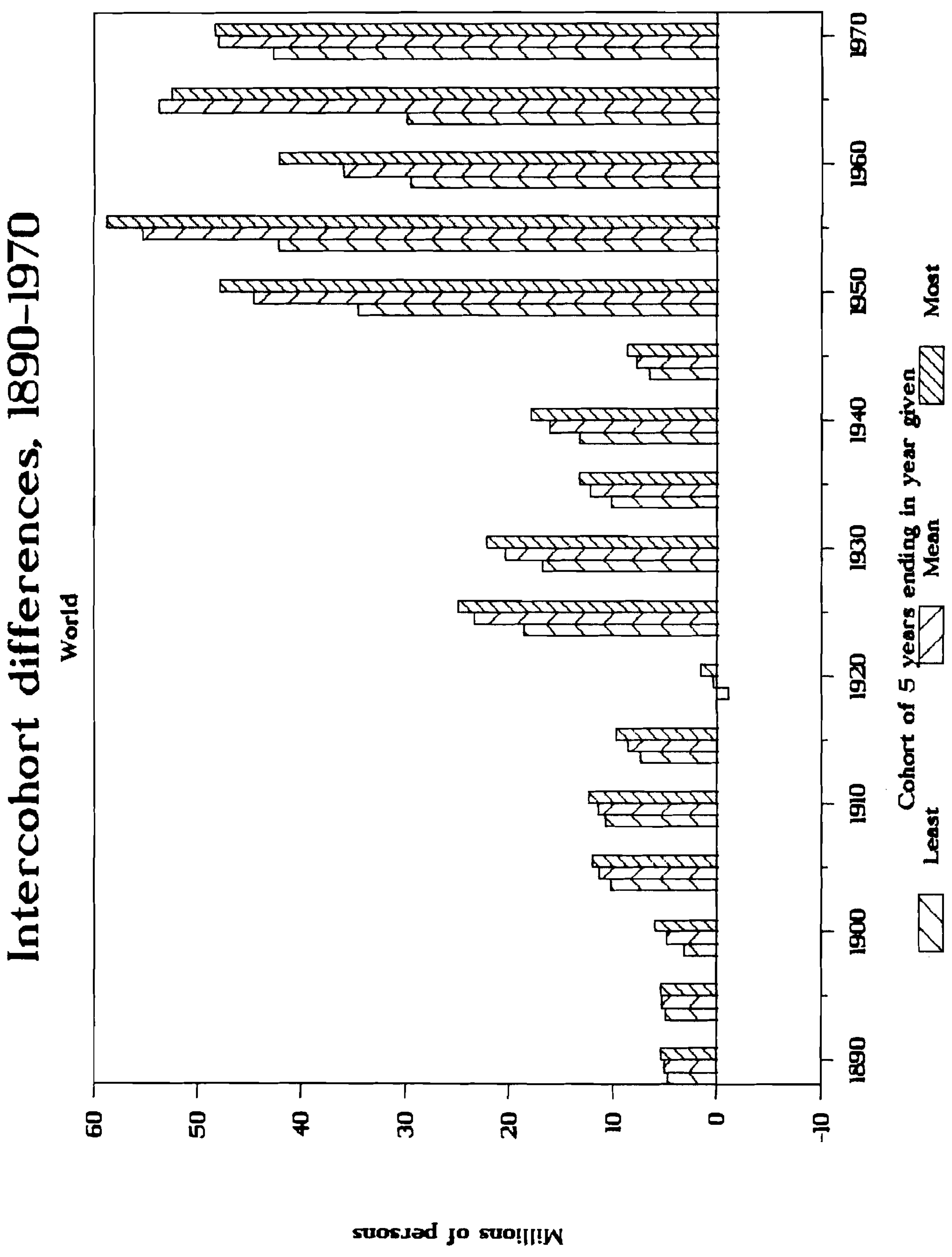
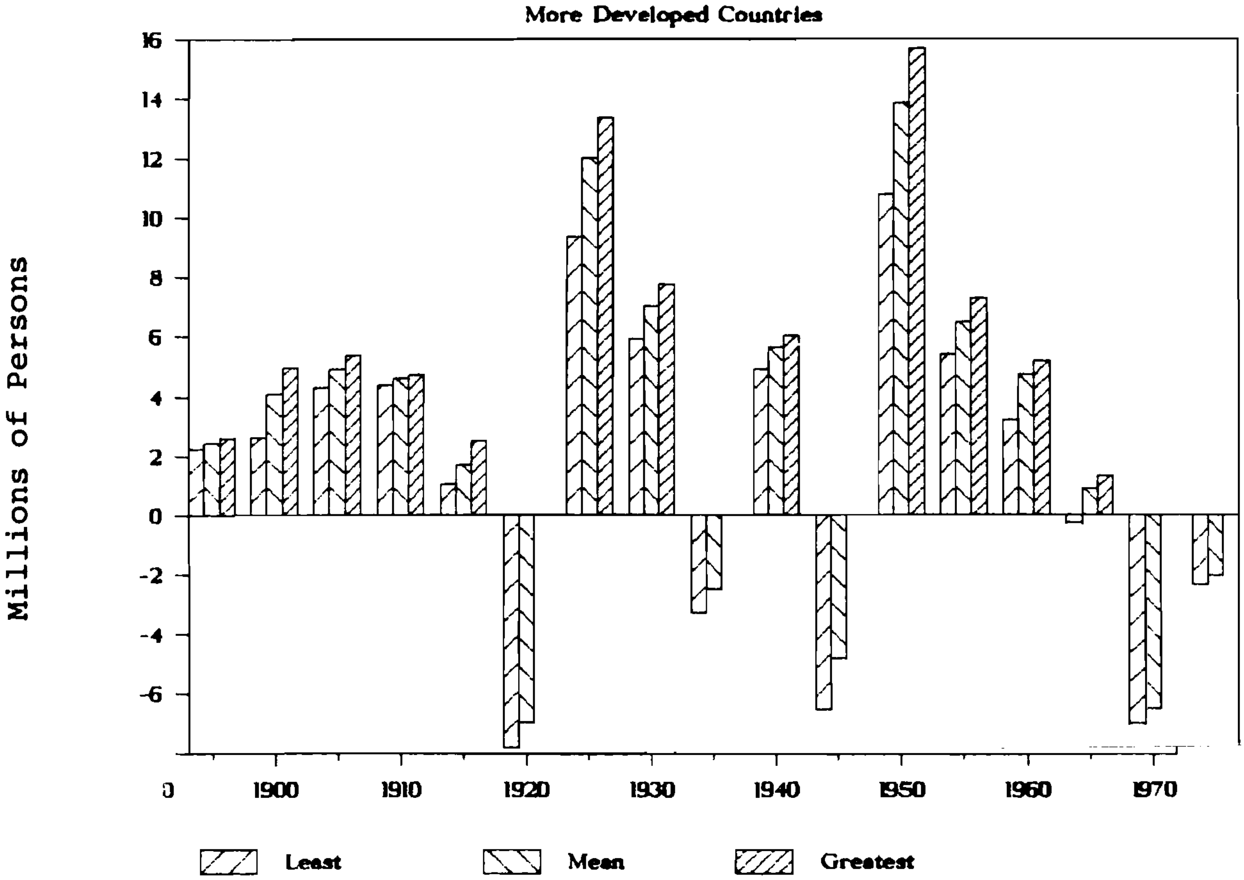
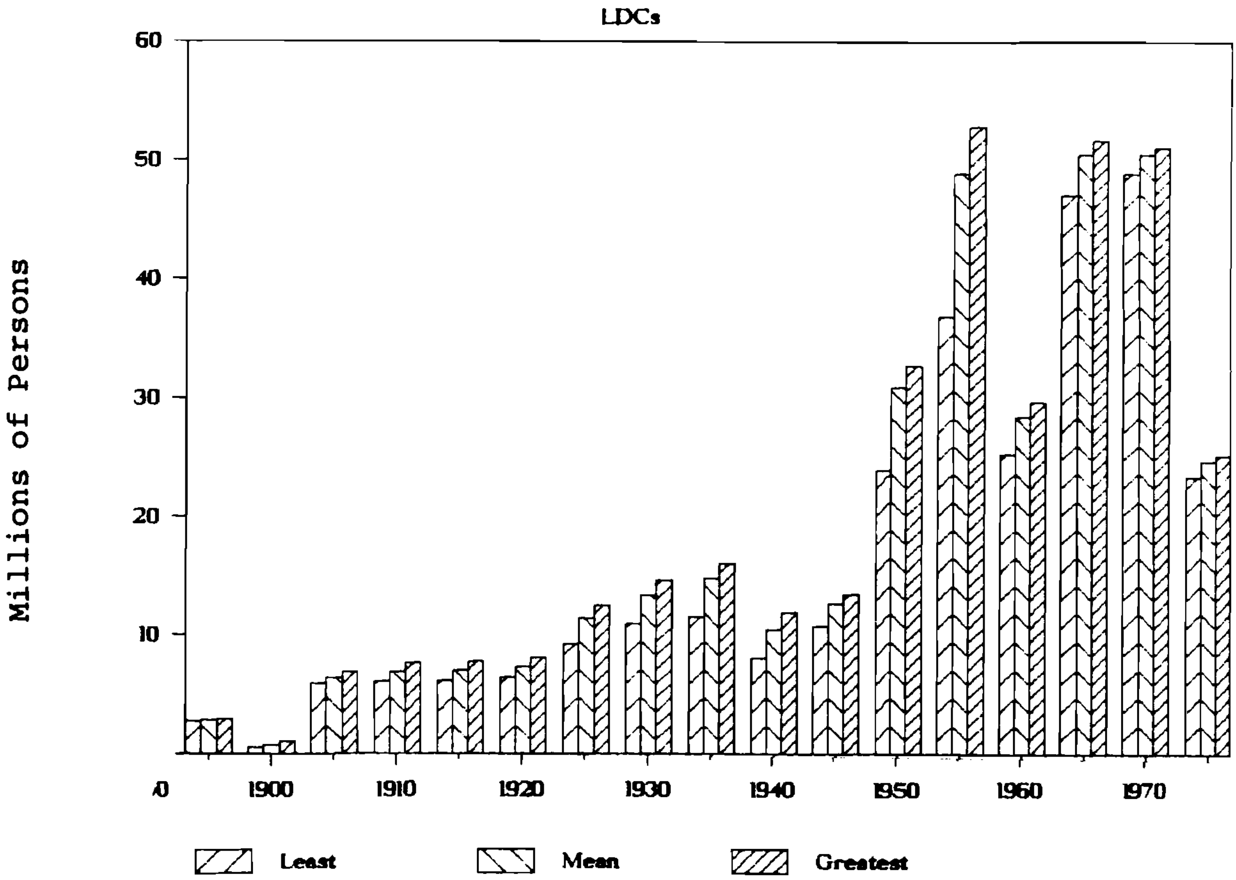


FIGURE 2A. Intercohort increases 1890-1970, as calculated from population age distributions 1950-2020 estimated and projected by the United Nations (1986), more developed and less developed countries, millions of persons.





RECONSTRUCTION OF THE ORIGINAL AGE-PERIOD TABLE

The uniformity of the cohort-to-cohort differences provides an opportunity to reconstitute the conventional age-period data given as TABLE 1. Such a reconstitution is at one and the same time a test of what we can now consider as a model, and an opportunity to experiment with the model to see what amounts of cohort change are capable of producing the sharp discontinuity in rates of growth shown in TABLE 1.

The mean differences in the third column of TABLE 7 can be successively added to some initial population and so reconstitute the orignal age-time table. If we take the cohort born in the year 1945-50, shown as the main diagonal of TABLE 1, and repeated in TABLE 8 as the initial values for the model, then by successively adding the average intercohort differences shown as the third column of TABLE 7 we can build up the part of TABLE 1 above the main diagonal. By subtracting from that main diagonal, values taken from the same third column of TABLE 7 we can build up the part of TABLE 1 below the main diagonal, all to an approximation that is to be investigated. If it is possible to reconstruct TABLE 1 with 29 numbers from TABLE 7(and its continuation, not here shown), plus a column of 15 numbers for starting values given as the main diagonal of TABLE 1 and repeated as TABLE 8, then we have a greatly improved chance to analyse and compare continents and countries. With 29 plus 15 = 44 numbers rather than the 17 x 15 = 255 intercountry and other differences should come out more clearly.

What this amounts to is that the numbers provided by TABLE 7 being differences we need starting values to attach them to and TABLE 8 provides those indispensable starting values. In a further development these starting values will be a suitable cohort life table survivorship, but for want of data on the world as a whole they are here simply taken from the original TABLE 1. TABLE 9 shows the reconstructed cohorts, intended to approximate TABLE 3. In TABLE 9 there is no limitation to the diamond form of TABLE 3 since we have released outselves from the data restrictions of that table, and TABLE 10 could be extended to later and earlier years. The technique may have some potential for forecasting.

The calculation is unconventional, in that it uses absolute differences rather than the more usual ratios, and these include the effects of mortality and fertility changes. Yet the error of this process is small, as the reconstruction will show, and it has the advantage of being linear, and hence additive. The additivity will enable us to trace any peculiarity, in particular the discontinuity of the 1940s, down to the continents, countries etc. that make up the total.

TABLE 8. Cohort born 1945–50, that serves as base for reconstruction; world as a whole (millions of persons).

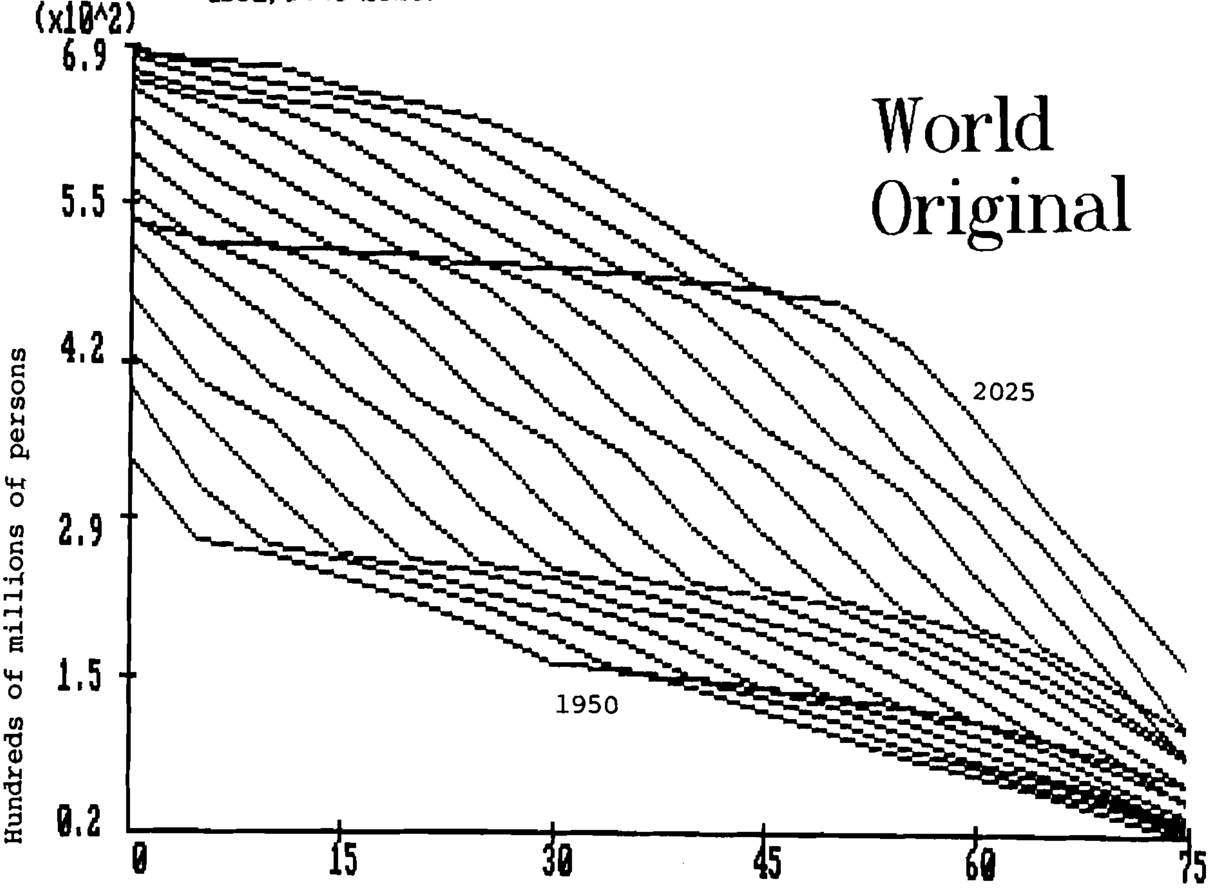
Age	
0-4	341
5-9	317
10-14	312
15-19	307
20-24	301
25-29	296
30-30	292
35-39	287
40-44	282
45-49	276
50-54	268
55-59	257
60-64	241
65-69	220
70-74	189

TABLE 9. Reconstruction of the cohort arrangement of TABLE 3, using only the third column of TABLE 7 and the decrement information of TABLE 8; world as a whole (millions of persons).

	Cohort born in five years preceding the year						
Age	1930	1935	1940	1945	1950	1955	1960
0-4	-	-	-	-	341	386	429
5-9	-	-	-	273	317	373	406
10-14	-	-	280	267	312	367	400
15-19	-	239	255	263	307	363	396
20-24	221	233	249	257	301	357	390
25-29	215	227	244	251	296	351	384
30-34	211	223	239	247	292	347	380
35-39	206	218	235	242	287	342	375
40-44	201	213	229	237	282	337	370
45-49	195	207	223	231	276	331	364
50-54	187	199	215	223	268	323	356
55-59	176	188	204	212	257	312	345
60-64	161	173	189	197	241	297	330
65-69	139	151	167	175	220	275	308
70-74	108	120	138	144	189	244	-

Now all that is needed is to offset the successive rows of TABLE 9 in such a fashion as to line up points of time under one another, and we end with TABLE 10. This last step is the reverse of that by which TABLE 3 was derived from TABLE 1.

FIGURE 3. Age distributions as given by the United Nations, and as reconstructed from intercohort increases of TABLE 7, shown in FIGURE 2, and base of 1945-50 cohort, world as a whole, millions of persons. No other data used, 1950-2025.



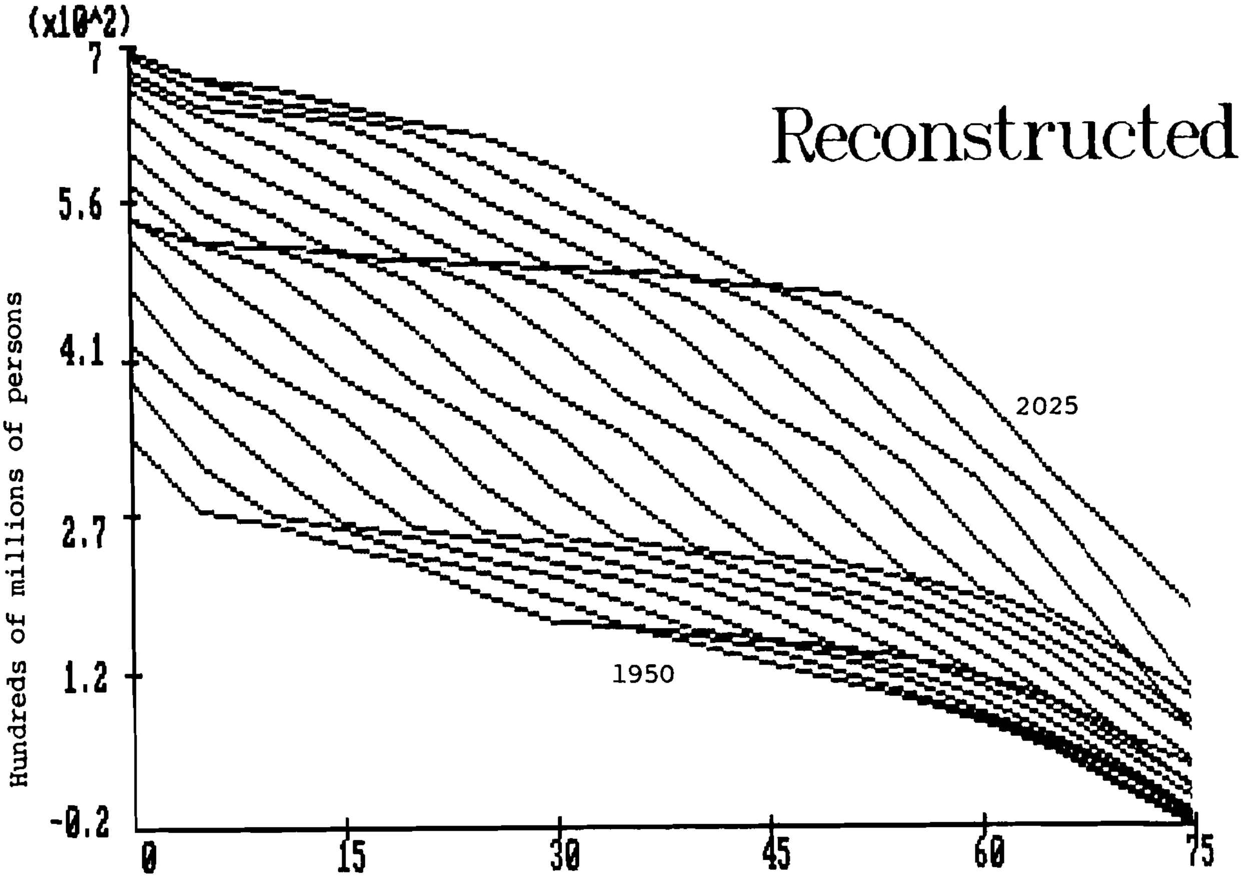
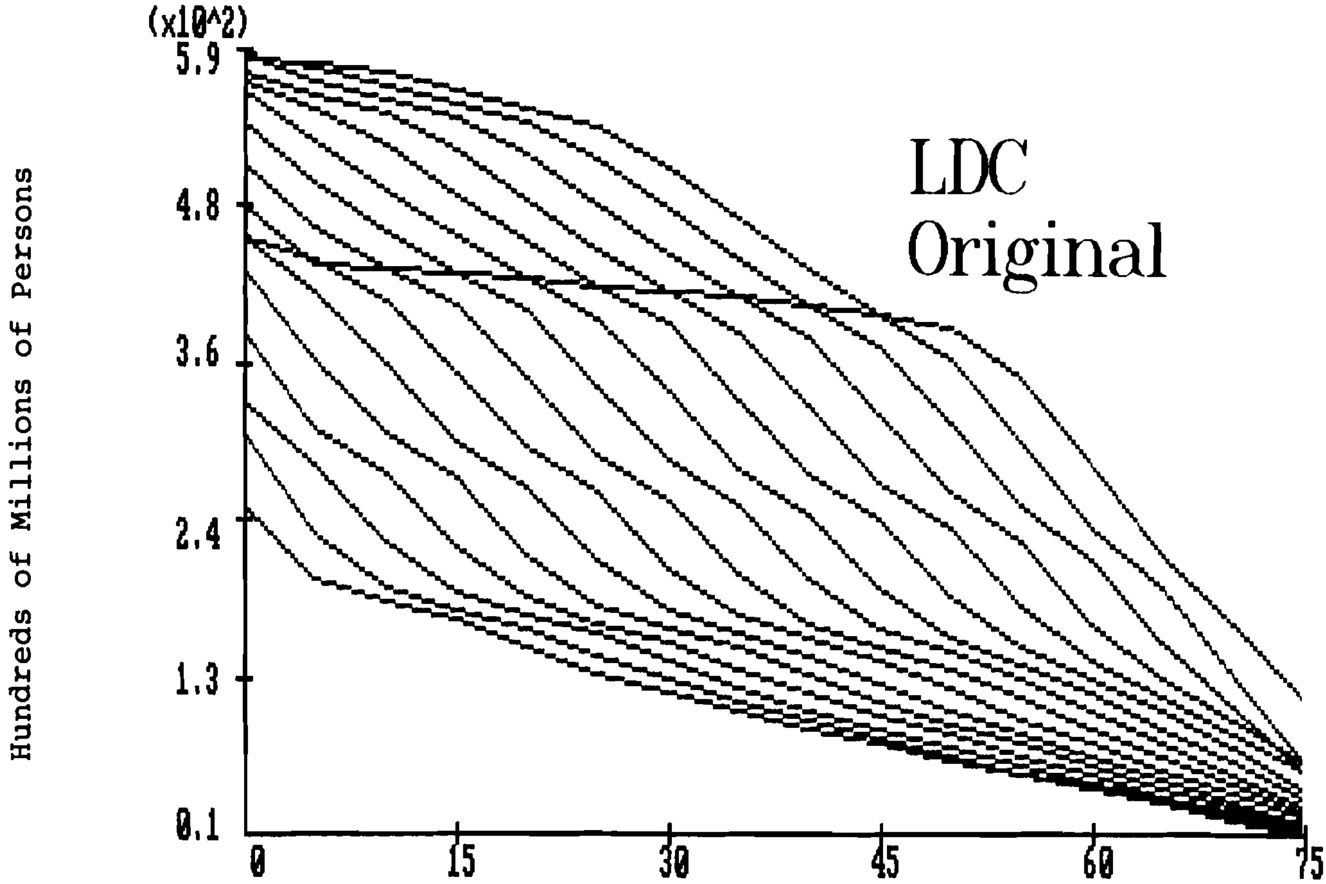


FIGURE 4. Original age distributions (as estimated and projected by the United Nations) and age distributions as reconstructed from intercohort increases and base of 1945-50 cohort, aggregate of Less Developed Countries, 1950-2025.



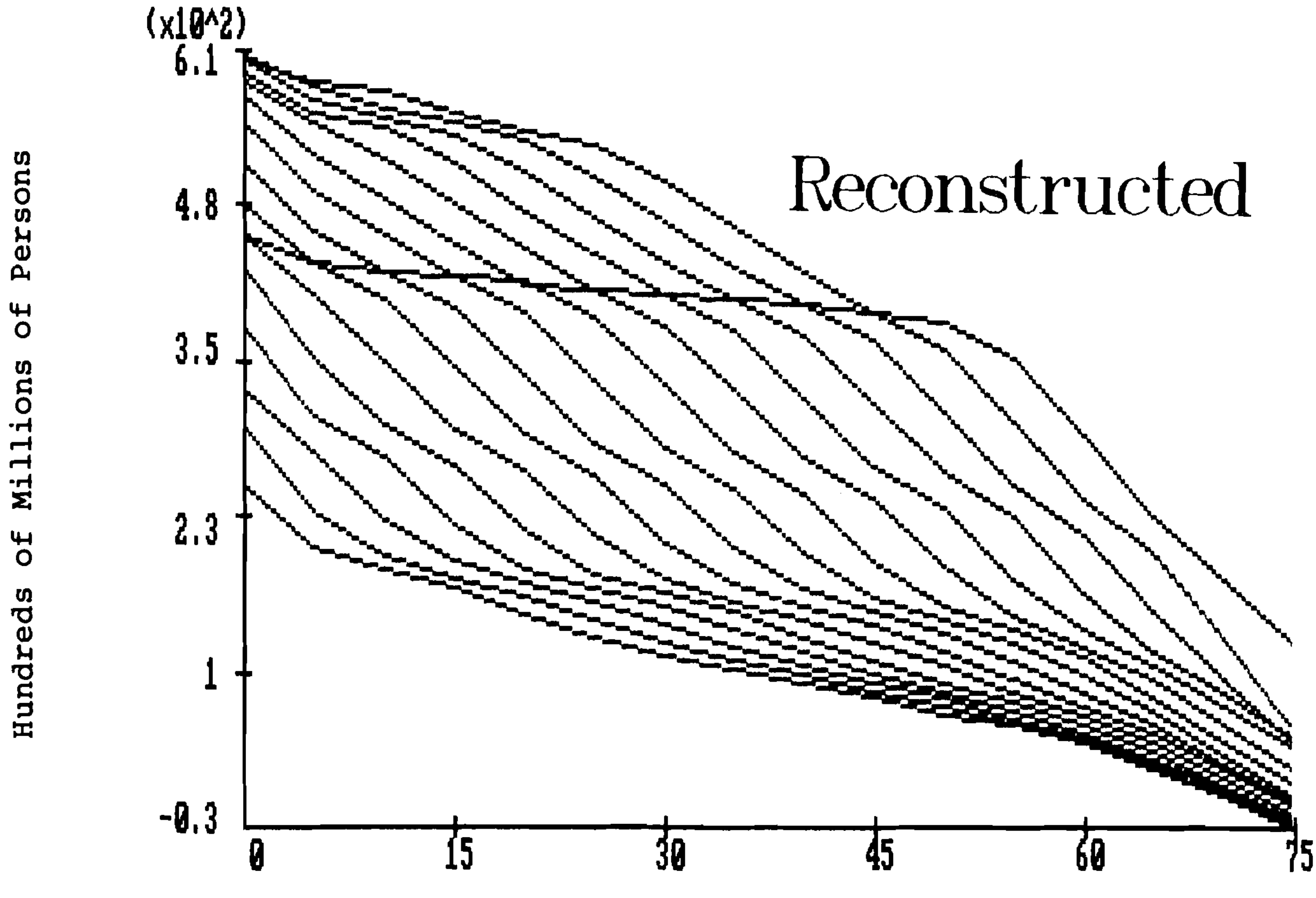


TABLE 11 shows the departures of the reconstruction from the original. The places where the fit is less than satisfactory are the rows near the beginning and end, the places in the table most affected by changing mortality. Correction can be made for changing mortality, but the present study does not require it.

TABLE 10. Reconstruction of TABLE 1; world as a whole (millions of persons).

Age	1950	1955	1960	1965	1970	1975	1980
0-4	341	396	429	481	525	547	545
5-9	273	317	373	406	457	501	523
10-14	260	267	312	367	400	452	496
15-19	239	255	263	307	363	396	447
20-24	221	233	249	257	301	357	390
25-29	195	215	227	244	251	296	351
30-34	167	191	211	223	239	247	292
35-39	162	163	186	206	218	235	242
40-44	148	157	157	181	201	213	229
45-49	131	142	151	151	175	195	207
50-54	112	123	134	143	143	167	187
55-59	96	101	112	123	132	132	156
60-64	75	80	85	97	108	117	117
65-69	48	53	59	63	75	86	95
70-74	13	18	23	28	33	44	55

TABLE 11. Discrepancy of reconstruction: period arrangement giving departure of TABLE 10 from TABLE 1; world as a whole (millions of persons).

Age	1950	1955	1960	1965	1970	1975	1980
0-4	0.	-3	0.	3	3	4	5
5-9	2	0	-3	-1	-2	-2	-3
10-14	2	3	0	-3	-3	-4	-4
15-19	-1	2	3	0	-2	-4	-4
20-24	0.	-0.	2	2	0	-3	-4
25-29	0.	1	0.	2	3	0	-3
30-34	3	2	3	2	3	2	0
35-39	3	4	3	3	3	2	2
40-44	4	5	6	4	3	3	1
45-49	5	6	6	6	5	3	3
50-54	6	6	6	6	6	4	2
55-59	7	6	5	4	3	4	3
60-64	2	2	1	1	0.	-1	-1
65-69	-7	-7	-8	-7	-8	-8	-8
70-74	-25	-25	-25	-25	-23	-22	-21

Having developed the method, we can go on to obtain a profile, similar to that given by the third column of TABLE 7, for the several continents.

GEOGRAPHIC DECOMPOSITION OF THE DISCONTINUITY

Since the whole of our calculation is linear, the discontinuity ought to be allocatable without residue to the several countries and continents.

As an example, in TABLE 12 we find that the 1920 number for the world is 3, and this is the net balance between -70 for the MDCs and 73 for the LDCs, all in thousands. In the following cohort we have an increase to 233 for the world, i.e. the increase increased by 233 - 3 = 230. Corresponding numbers for the MDCs were 190 and 40. There was a discontinuity for the world as a whole, and it was over 80 per cent due to the developed countries. Very different was the discontinuity of the 1940s, that was at least half due to the LDCs.

The conveniently additive character of the measure of cohort change permits us to partition the total at any point. Thus of the 1885 increase of 45 (hundred thousands) 22 is in the MDCs and 23 in the LDCs, both as presently classified (first row of TABLE 12).

Evidently the discontinuity that starts for the world with the cohort born 1945-50 appears both in the MDCs and the LDCs, but the latter have much more weight. For the MDCs, moreover, it is only one item of a series of repeated and irregular fluctuations. For the LDCs the cohort of 1945-50 initiates a level that is from 2 to 4 times that of the preceding decades. For these latter there is a decisive rise from the line marked 1945 to that marked 1950, and another from 1950 to 1955.

It seems to have been the baby boom, starting just after the war, and ending with the cohort of 1955-60, that joined in with what was happening in the LDCs to give such a decisive turn to the picture for the world as a whole.

As among the continents, Africa shows no discontinuity, but rather a steady acceleration, and something of the same kind can be said, though less emphatically, about Latin America. It is Asia that is more than any other continent responsible for the discontinuity in the world picture.

The sudden rise that began with the 1920-25 cohort is more uniformly spread around the continents, with Europe having an especially large part of it.

TABLE 12. Average amount of increase of successive cohorts, as estimated from available ages, for cohorts born in the five years preceding 1885 to cohorts born the five years before 1970 (hundreds of thousands of persons).

	World	MDC	LDC	Africa	Asia	Lat Am	Europe	N. Am.
1885	45	22	23	1	21	3	9	7
1890	50	25	25	1	20	5	11	7
1895	52	24	28	2	23	4	9	7
1900	48	41	7	5	0.	7	24	3
1905	113	49	64	6	54	8	24	6
1910	114	46	68	7	57	7	16	11
1915	86	17	69	9	54	11	-6	9
1920	3	-70	73	11	56	7	-54	7
1925	233	120	113	13	94	15	73	9
1930	203	70	133	18	115	14	5	-3
1935	122	-25	147	19	123	13	-1	-8
1940	161	56	104	21	67	17	7	6
1945	78	-48	126	24	89	21	-11	26
1950	447	138	308	36	249	37	46	39
1955	553	65	488	46	381	46	13	23
1960	330	47	283	57	167	46	10	22
1965	514	9	505	63	391	54	12	-2
1970	440	-65	505	81	400	30	-4	-29

And now for the countries where the events of World War II made an especially deep impression on the demography, reflected in the rise from 8,900,000 of the 1940-45 cohort to a rise of 24,900,000 for the cohort of 1945-50 (Table 12). Indonesia is an impressive case, and we see (TABLE 13) that the increase of the 1950 figure (representing the cohort born 1945-50) was 300 thousand, averaged over the 14 age-dates for which information (including UN projections) is available. In contrast to this the 1955 figure was 1900 thousand, averaged over 15 points of time and age, a six-fold rise.

China evidently made a major contribution to the mid-century discontinuity that shows in the world picture, India much less, Bangladesh and Pakistan less yet.

As far as the rise after World War I is concerned, the five countries in TABLE 13 show it weakly or not at all. Someone with better knowledge of the history of those countries about the turn of the century may be able to speculate more convincingly than can this writer about the events that are reflected in the cohort changes of TABLE 13. The only point that is worth mentioning again is that for each of the cohorts after the first one in the table (that for 1875-80) there are at least two points, and these are more or less independent, and in almost all cases agree closely with one another.

TABLE 13. Average increase between cohorts, based on population estimates and forecasts, from cohort born in five years before 1885 to cohort born in five years before 1970 (hundreds of thousands of persons).

Cohort	Bangladesh	China	India	Indonesia	Pakistan
1885	0.	17	-1	0.	-0.
1890	0.	6	10	0.	0.
1895	0.	13	7	0.	-2
1900	1	-21	10	0.	0.
1905	-0.	28	12	3	-0.
1910	5	15	17	4	2
1915	-1	19	18	3	2
1920	-1	25	20	1	1
1925	2	34	25	5	2
1930	3	35	31	9	4
1935	3	51	32	8	2
1940	3	8	26	8	3
1945	4	23	27	3	3
1950	4	130	47	3	6
1955	7	221	75	19	17
1960	18	-35	87	24	10
1965	11	207	78	14	13
1970	15	207	81	24	14

TABLE 14 shows the larger European countries in the same way. They show birth and mortality losses during each of the wars, and a boom at the end of each war. France's low birth rate of the 19th century comes through, as does that of the UK.

For individual countries of over 15 million population a sequencing was made of the sharpness of the bend in age distribution for different points of time. Four of the countries that showed sharp bends appear in FIGURE 5.

THE THREE-DIMENSIONAL GEOMETRY OF THE DISCONTINUITY

Some understanding of the argument of this paper can be obtained from the three-dimensional representation of such numbers as those of TABLE 1, or functions of them. FIGURE 7 charts first differences, and its even ridges correspond to the uniformity down diagonals of TABLE 2 and the uniformity down columns of TABLE 3. The greater uniformity of Tables 5 and 6 corresponds to a different angle on the ridge.

TABLE 14. Average increase between cohorts, based on population estimates and forecasts, from cohort born in five years before 1880 to cohort born in five years before 1970. Major countries of western Europe. Thousands of Persons.

Cohort	France	W. Germ.	Italy	Spain	UK
1880	66	92	179	41	75
1890	51	187	125	108	55
1895	53	239	65	47	92
1900	283	446	197	172	190
1905	240	464	242	114	302
1910	30	184	387	115	155
1915	-289	-244	155	53	-36
1920	-751	-1126	-767	4	-352
1925	1221	1111	1042	295	321
1930	8	62	43	147	-323
1935	-19	-7	-39	187	-162
1940	-231	968	152	-191	64
1945	-33	-546	-321	-65	208
1950	1203	-346	517	278	635
1955	3	338	-236	90	-382
1960	0.	381	197	280	262
1965	84	579	441	260	451
1970	-103	-306	-10	111	-151

THE MODEL AS A BASIS FOR EXPERIMENTS

Plainly the full detail of the data is not needed in order to produce on a chart the discontinuity here under study, and it is illuminating to produce it with the minimum of data, even no data at all. Suppose that instead of the age distribution of the cohort born in 1945-50 we take as the starting point the geometric progression 20, 16, 12.8, 10.24, ... Beyond that let the profile (that we have taken as the third column of TABLE 7 in the reconstruction) consist in 1 for all cohorts up to 1940-45, and 3 for all cohorts beyond (FIGURE 6). This provides a discontinuity in the increases of about the order of magnitude of that shown in some LDCs.

The plan for further experimenting is to try conditions more realistic than those of FIGURE 6, but short of the use of actual data. In particular one would like to see what kinds of changes in birth rates, and in age specific mortality rates, will produce the bend actually observed. No one expects that a unique answer can be found to the question "What changes in birth and death rates brings about the age distribution?" and what will be sought is the range of possibilities.

FIGURE 5. Age distributions 1950-2025, four populations leading in sharpness of discontinuity: Malaysia, Pakistan, Egypt, Turkey.

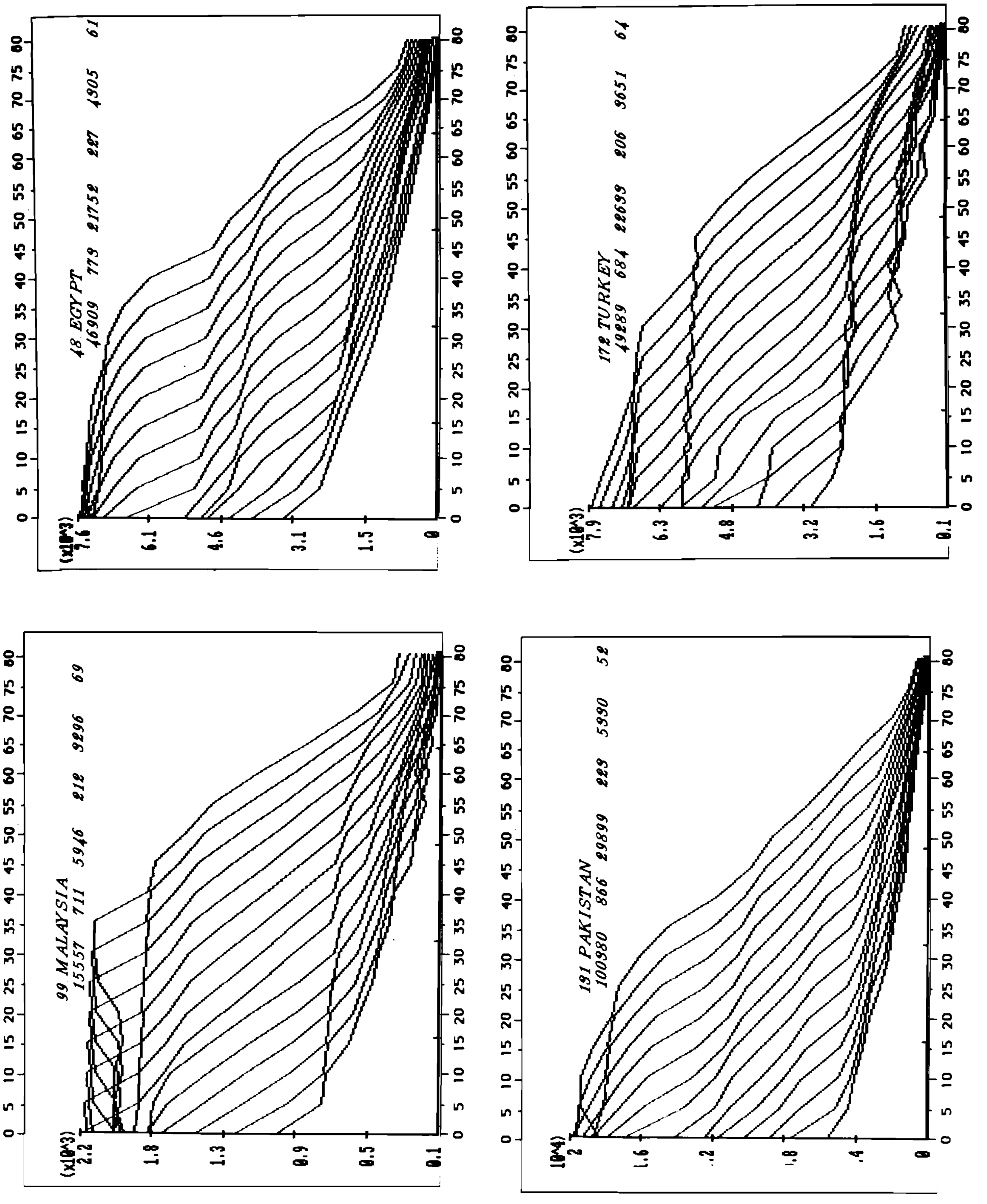


FIGURE 6. Synthesized set of age distributions, based only on initial values 20, 16, 12.8, 10.24, ..., and on change of 1 per five years from 1880 to 1945, and 3 from 1945 to 2020. No actual data used.

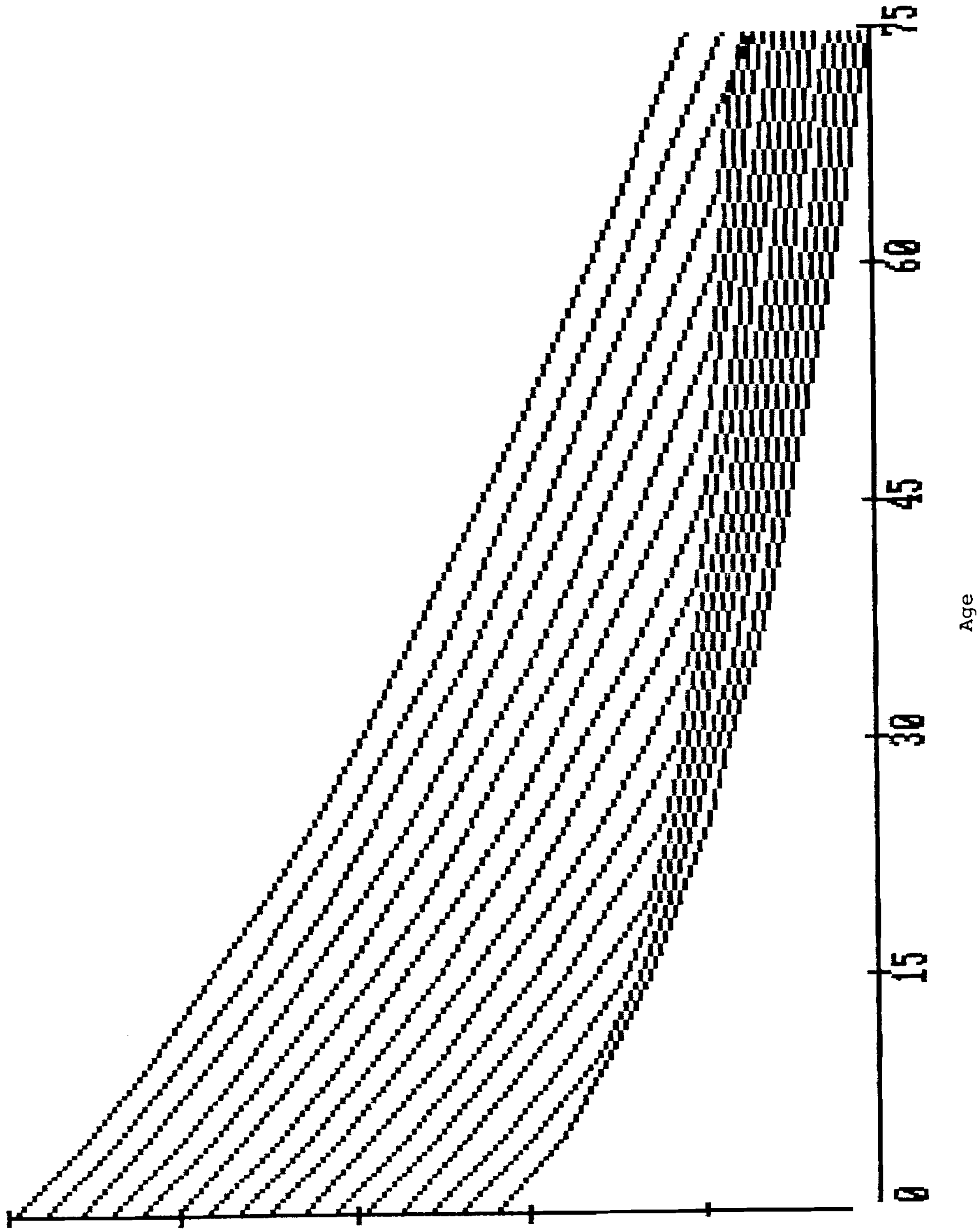
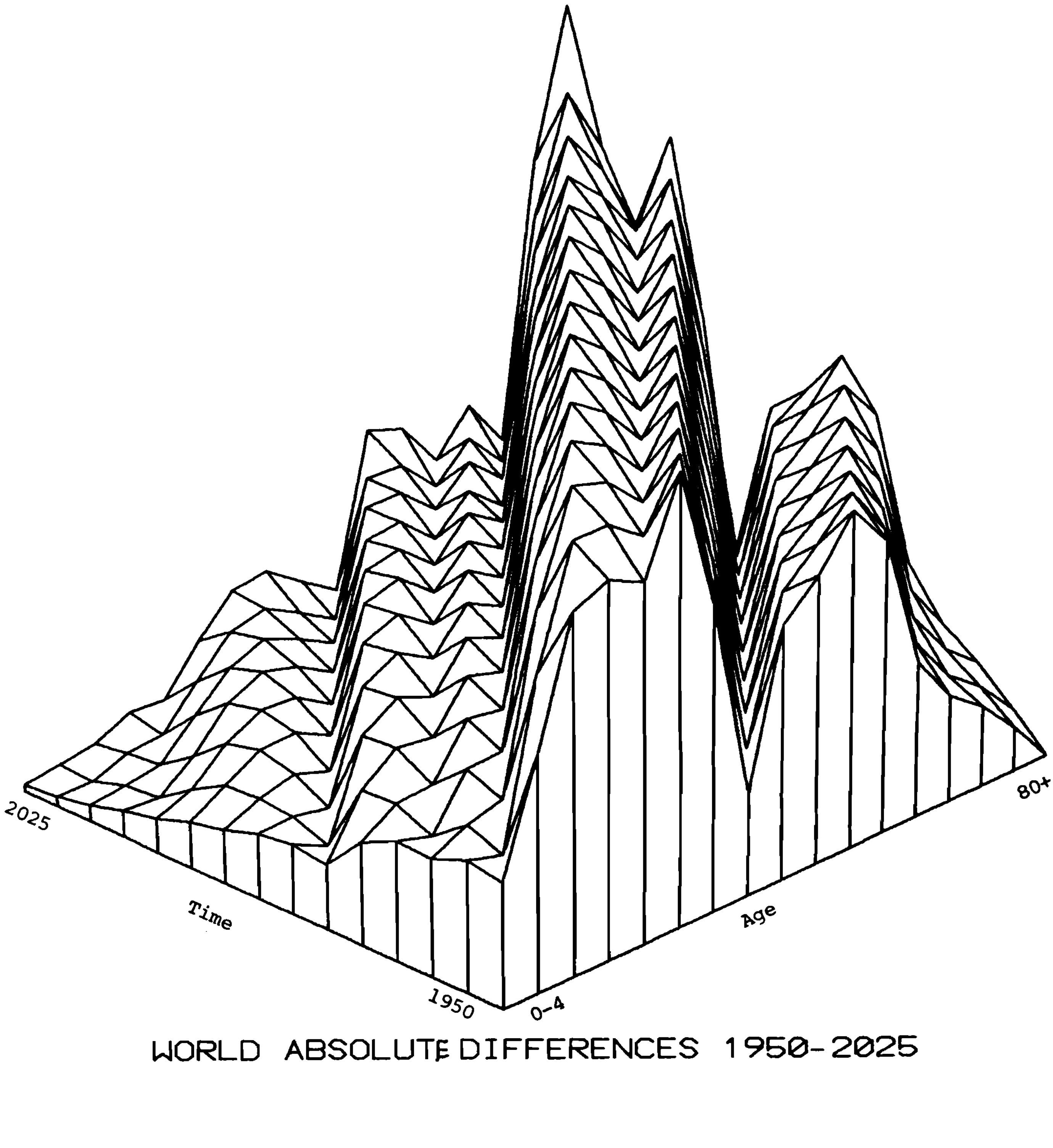


FIGURE 7. Three-dimensional representation of age-time distribution corresponding to TABLE 1 (prepared by Wolfgang Lutz).

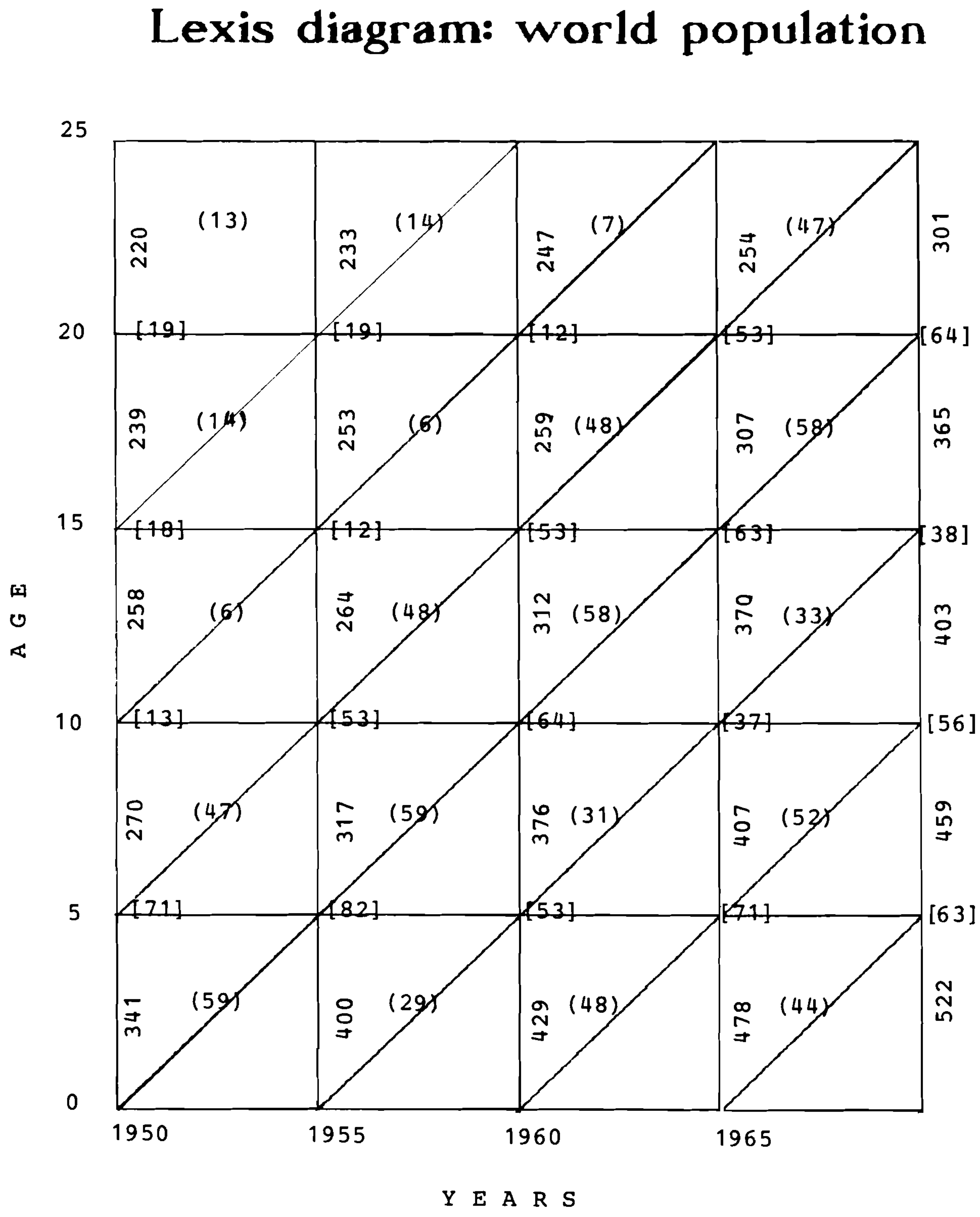


APPENDIX

The Lexis diagram (FIGURE 8) shows some of the cells of Tables 1-5. For example on the lowest row, the 0-5 counts, for 1950 we have 341 million; for 1955 at age 5-9 we have 317 million. These both concern the cohort born in 1945-50, and we expect them to include the mortality loss by age as their difference. When we compare these losses we find along horizontal lines the differences given in parenthesis, and along cohort lines these come close to constancy. The differences between the 1950-55 cohort and the prece.,ding, along a diagonal, comes out as 59, 59, 58, 58 when estimated from the successive censuses as in Table 5. When the intercohort differences are estimated from one census at a time, as in Table 2, they also show some uniformity, but not as much (Figures in square brackets).

The differences that appear in the diagram have their uniformity as a result of combining mortality and fertility change. It is planned to separate these in later research, but for the present purpose such separation is unnecessary.

FIGURE 8. Lexis diagram: world population



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