V. ESTIMATION OF CURRENT LEVEL AND FUTURE TREND OF FERTILITY

A. The measurement of fertility

245. In addition to the calculations concerning future numbers of survivors from various sex-age groups of the present population, a "component" projection requires estimates of the numbers of children to be born during successive future periods. These estimates are derived from the estimated numbers of surviving females in the childbearing ages at each future date, with assumptions as to their fertility.

1. *The relevance of alternative fertility measures for population projections*

246. Where statistics of birth by age of mother are available, calculations with respect to fertility for population projections are usually made in terms of specific birth rates for various age groups of the female population. These rates are calculated for a past period and either assumed to remain constant in the future or projected by means of suitable assumptions as to their expected trends; the future rates are then multiplied by the estimated numbers of female survivors in the corresponding age groups to obtain the estimated numbers of births. However, a current measure of age-specific birth rates cannot be obtained from the vital statistics of most countries. We shall therefore have to be concerned here mainly with the use of cruder measures.

247. The simplest measure of fertility is the crude birth rate, that is, the numbers of births annually per 1,000 of the total population. The use of this measure for estimating the future numbers of births, however, fails to take into account the results of the survivorship computations with respect to any expected future changes in the proportion of the population that consists of women in the childbearing ages. It is better for this purpose to measure fertility in terms of the annual number of births per 1,000 women of childbearing ages. The calculation of this measure requires a choice of upper and lower limits for the childbearing ages. In most circumstances, it is appropriate to let the childbearing group be represented by the female population 15-44 years old. Some births occur to girls under 15 years of age and some to women over 45, but it is not expedient to include all the ages at which any woman may bear children, for the estimated future numbers of births might then be unduly influenced by variations in the numbers of women at the extremes of the potentially fertile period, who would in any case produce very few children. Narrower limits may be more suitable in some cases; for example, where women rarely marry before the age of 18 or 19 years, better results may be obtained by taking the female population 20 to 44 years of age to represent the childbearing group.

248. Although estimates of future births based on projected rates per 1,000 women of childbearing ages take full account of changes in the size of this segment of the population, they do not take account of any changes which may be expected in the age distribution of the women within this group. Such changes may be important because fertility varies greatly with the age of women; it is always much lower, for example, in the case of women 35 to 44 years of age than of women 20 to 29. The only way to take changes in the age distribution fully into account is to make separate estimates of the future fertility rates for women in each age group, but where this cannot be done for lack of adequate data, an approximate compensation for the effects of changing age distribution can be introduced by making the computations in terms of a modified birth rate.

249. The United Nations projections were made by means of such a modified rate, called the "sex-age adjusted birth rate". Its derivation is explained below, and the discussion in the subsequent sections of this chapter is based, for the most part, on the assumption that this or some similar measure of fertility is to be employed. It is better, however, to make the calculations in terms of age-specific birth rates where the necessary data are available, and for those countries which have very detailed statistics, still more elaborate measures of fertility measures may be utilized. At this point it is relevant to consider very briefly some alternative measures and the situations in which it may be advantageous to use them if possible.

250. Given the necessary data, marital fertility rates may be calculated for married women of various ages and illegitimate birth rates for unmarried women, and these may be applied to estimates of future female population classified by marital status within each age group. Further classifications may be introduced, where the data permit, to show the distribution of married women by duration of marriage and number of children already born to them, and to measure their fertility in relation to these variables. Such measures are appropriate where substantial changes have occurred, or are expected to occur, in marriage rates, age at marriage, or the timing of births.

251. Changes in the timing of marriages and births—usually in response to changing economic conditions—may have cumulative effects on age-specific fertility rates. As an example, we may consider the effects of a tendency of women to marry at younger ages than previously. At first, the number of marriages will increase as the marriage rates for the youngest age groups rise while the older women continue to marry as before, but eventually, once the new pattern has become prevalent, the number of women marrying at older ages falls off, most women already being married before they attain those ages, and so the annual number of marriages returns to normal with a changed distribution by age at marriage. This "staggering" effect of a change in marriage habits will affect the birth rate, producing temporary variations in the number of births and their distribution by birth order, as well as a long-range effect due to the relationship between fertility and age at marriage. Soon after the increase of marriages, there is likely to follow a temporary increase in the number of first births; after a time, the number of second births will rise, etc. These and other possible effects of changes in demographic factors must be kept in view when deciding what fertility measure it is most appropriate to employ in a given situation.

2. *The "sex-age adjusted birth rate"*

252. The "sex-age adjusted birth rate"[41] used for the United Nations projections is defined as the number of births per 1,000 of a weighted aggregate of numbers of women in the various five-year age groups from 15 to 44. A standard set of weights is used in computing this aggregate, the weights being roughly proportional to the typical relative fertility rates of the various age groups, as determined by examination of the available statistics of births by age of mother for various countries.

253. The use of a standard system of weights for this purpose is justified by the observation that, even under greatly differing conditions of fertility, the relative levels of age-specific rates for women in the age groups from 15-19 to 40-44 are not very different. The absolute levels of these rates, of course, are higher where fertility is high than where it is low, yet on the whole the percentages of all births occurring to women in a given age group are rather similar.[42] An illustration is given by the comparison of age-specific fertility rates for France in 1936 and Formosa in 1950, shown in table 23.

TABLE 23. ABSOLUTE AND RELATIVE AGE-SPECIFIC FERTILITY RATES FOR WOMEN 14 TO 44 YEARS OF AGE: FRANCE, 1936 AND FORMOSA, 1950

Age of women (years)	*Live births per 1,000 women*		*Relative rate (total, 15–44 = 100)*	
	France, 1936	*Formosa, 1950*	*France, 1936*	*Formosa, 1950*
Total, 15–44[a]	406.6	1,170.5	100.0	100.0
15–19	27.2	60.9	6.7	5.2
20–24	120.6	245.0	29.7	20.9
25–29	119.2	295.8	29.3	25.2
30–34	79.3	266.9	19.5	22.8
35–39	44.6	191.5	11.0	16.4
40–44	15.7	110.9	3.9	9.5

[a] Total of age-specific rates, excluding those of females aged less than 15 or 45 and over.

254. The relative rates are quite similar, although Formosan fertility in 1950 was almost three times that of France in 1936.

255. Relative rates have been computed for 52 countries, utilizing all the data on births by age of mother available in the *Demographic Yearbook*.[43] Averages were obtained for each country for all the years for which the data were given. These averages were averaged again for a group of 15 countries having comparatively high fertility, a group of 37 countries with relatively low fertility, and for all 52 countries combined. The variability in each of the relative rates among the 52 countries was also examined and the mean deviation from the average was computed. The results are presented in table 24. It will be noted that the variability of the relative rates is most important in the age groups 15-19 and 40-44 and is quite small in the age range from 20 to 39 years.

TABLE 24. RELATIVE AGE-SPECIFIC FERTILITY RATES OF WOMEN, AVERAGED FOR GROUPS OF COUNTRIES, AND WEIGHTS SELECTED FOR FERTILITY MEASURE

Age of women (years)	*Average of relative fertility rates*			*Mean deviation from average (total, 52 countries)*	*Weights for computation of adjusted birth rates*[a]
	Total, 52 countries	*15 countries of high fertility*	*37 countries of low fertility*		
Total, 15–44	100.0	100.0	100.0	...	...
15–19[b]	6.3	9.3	5.1	±2.7	1
20–24	25.3	25.1	25.4	±3.5	7
25–29	27.6	25.5	28.5	±2.1	7
30–34	21.1	19.6	21.7	±2.1	6
35–39	13.4	13.7	13.2	±2.1	4
40–44[c]	6.3	6.9	6.0	±2.2	1

[a] The method of selection of weights is explained in the accompanying text.
[b] Including an allowance for births to mothers below age 15.
[c] Including an allowance for births to mothers aged 45 and over.

256. The weights shown in the last column of table 24 are those used in computing the sex-age adjusted birth rates for the United Nations projections. Since it was considered convenient that these synthetic rates should be of the same order of magnitude as crude birth rates per 1,000 of the total population, the weights were so chosen, not only that they would be roughly proportionate to the averages of the age-specific birth rates,[44] but also that the sum of their products with the corresponding numbers of women in the various age groups would ordinarily be of the same order of magnitude as the total population. The computation of the weighted aggregate of women and the sex-age adjusted birth rate is illustrated in table 25 with data for Cyprus. In this example, the sum of products of the weights and the numbers of women in the various age groups is very nearly the same as the total population, which was officially estimated to be 484,714 at mid-year 1950. If the weighted sum of women happens to equal the total population, the adjusted birth rate will equal the crude birth rate; it will exceed the crude rate if the weighted sum is smaller, and it will be smaller than the crude rate if the weighted sum is larger, than the total population. In the case of Cyprus, the crude birth rate was 29.95 per 1,000.

[41] In the two reports on future population estimates previously cited, this measure was referred to as a "standardized birth rate". This term is now avoided since it might create confusion where birth rates are standardized for different purposes by different procedures.

[42] Considerable derivations from the normal pattern may occur in unusual situations where, in response to a severe economic crisis, or as a result of war, births are postponed for several years, but compensated again when normal conditions have been restored.

[43] United Nations, *Demographic Yearbook, 1954*, table 11. The few births occurring before age 15 were included in the 15-19 group, and the few births after age 45 in the 40-44 group.

[44] The weights are not strictly proportional to the average relative rates for all countries but, in view of the mean deviations, they are not inconsistent. They would imply the following set of age-specific relative rates: 3.8 for women aged 15-19; 26.9 for women 20-24; 26.9 for women 25-29; 23.1 for women 30-34; 15.4 for women 35-39; and 3.8 for women 40-44. Because of variability in relative rates at ages 15-19 and 40-44, it was deemed advisable to select somewhat lower weights for these two age groups than suggested by the series of observed averages. The exact weights suggested by that series would be 1.6; 6.6; 7.2; 5.5; 3.5; and 1.6. Experience shows that some modification of weights has only a slight effect on the weighted result (total, or average).

TABLE 25. COMPUTATION OF "SEX-AGE ADJUSTED BIRTH RATE" FOR CYPRUS, 1950

Age (years)	Female population, 1950[a]	Weight	Product	Registered births, 1950	"Sex-age adjusted birth rate"
15–19.....	22,438	1	22,438	...	...
20–24.....	21,465	7	150,255	...	...
25–29.....	18,964	7	132,748	...	...
30–34.....	16,896	6	101,376	...	...
35–39.....	15,555	4	62,220	...	...
40–44.....	14,286	1	14,286	...	...
TOTAL	...	...	483,323	14,517	30.04

[a] Data taken from the *Demographic Yearbook, 1952.*

257. To examine variations in the ratio of weighted sum of women to total population, computations have been carried out with respect to the 62 populations for which sufficient statistics by sex and age were presented in the 1954 issue of the *Demographic Yearbook*. For 25 of the 62 populations, the weighted sum of women differed from the total population by no more than 5 per cent; for 29, it differed by at least 5 but no more than 10 per cent; differences greater than 10 per cent were found in 8 unusual cases.[45] The average of the 62 computed ratios of weighted sum of women to total population was found to be 0.983.

258. Computations have also been carried out with respect to the annual estimates of the Swedish population by sex and age, the results of which are presented in table 26. Sweden's total population increased constantly from 1938 to 1954, but the weighted sum of women stopped increasing in 1942 and declined subsequently. The weighted sum was at first greater than the total population, but after 1946 it was smaller. Measured by crude birth rates, the trend of Swedish fertility shows a peak in 1944-1945, reached by a rapid rise of the rate after 1941, and followed by an almost equally rapid decline; crude birth rates in 1951-1954 were no higher than those in 1938-1941. In terms of the sex-age adjusted birth rate, the rise in fertility from 1941 to 1944 was steeper, and the subsequent fall, from 1945 to 1951, much slower. In 1951-1954 the sex-age adjusted birth rate stood at a level intermediate between that of 1938-1941 and 1944-1945. In other words, fertility in 1951-1954 was actually higher than in 1938-1941, even though the crude birth rate was no higher, owing to the effects of a changed sex-age structure. The trends of the crude and sex-age adjusted birth rates for Sweden are also illustrated in figure 1.

259. It is emphasized that sex-age adjusted birth rates are only a simple device for eliminating the effects of changes in sex-age structure in a measurement of the fertility trend and an estimation of future births. They continue to be affected by such demographic factors

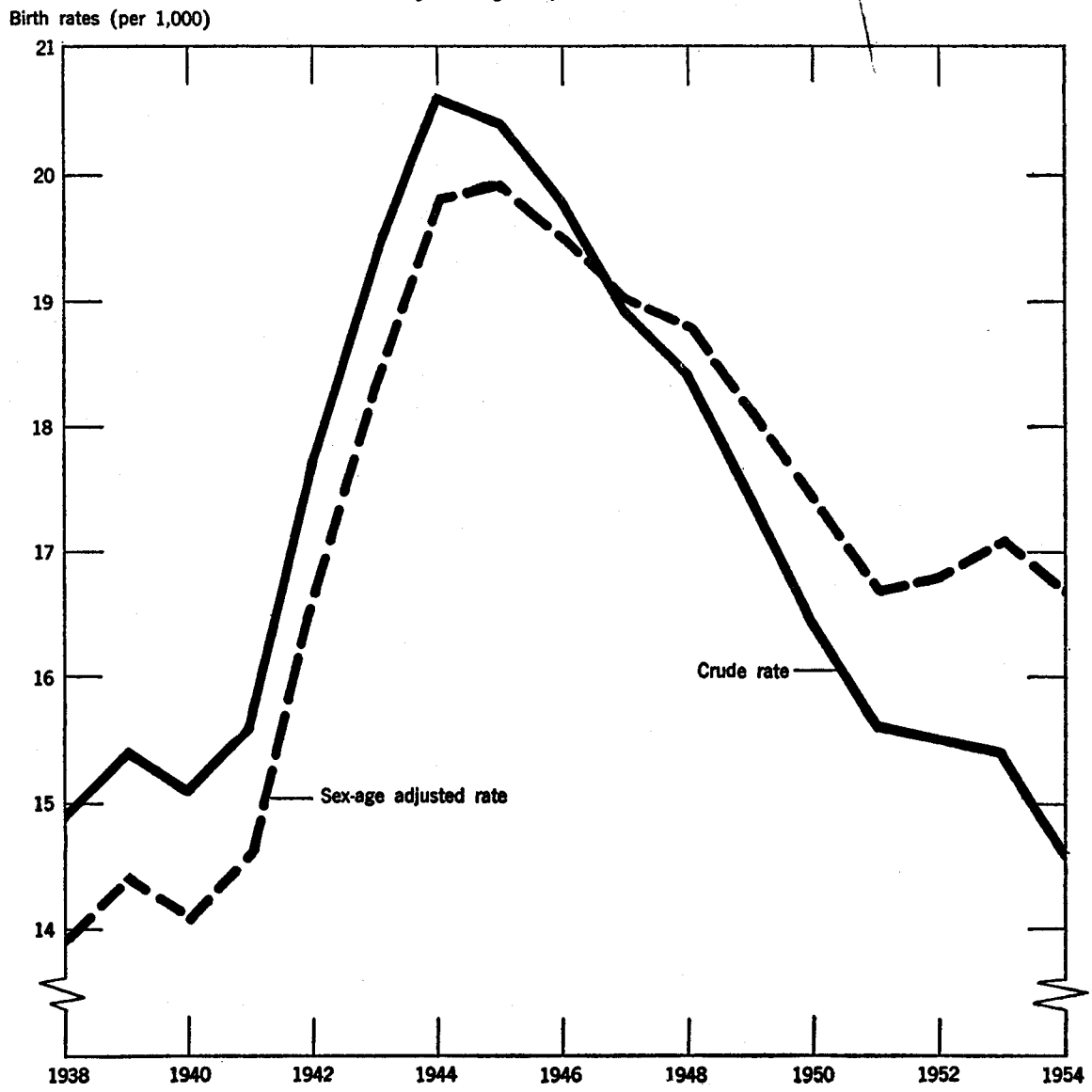
[45] These cases and the ratios of the weighted sums to the total population were: French Equatorial Africa, non-indigenous population (census 1951): 1.171; French West Africa, non-indigenous population (census 1951): 1.130; Northern Rhodesia, European population (census 1951): 1.125; Spanish Guinea, white population of the territory and indigenous population of Fernando Po (census 1950): 0.882; Haiti (census 1950): 1.111; France (estimate 1953): 0.896; West Berlin (estimate 1953): 0.803; and Gibraltar (census 1951): 1.149; The unusual sex-age structures of European settlements in African territories and Gibraltar are not surprising. The high ratio noted in the case of Haiti is perhaps largely a result of very incomplete child enumeration at the Haitian census. Low birth rates in France in the 1920's and 1930's and, in addition to past low birth rates, the selective effects of migration in West Berlin, are responsible for the fact that the age structure of the latter two populations is particularly conducive to a low crude birth rate.

TABLE 26. TREND OF SWEDISH FERTILITY, 1938–1954, AS MEASURED BY CRUDE AND BY SEX-AGE ADJUSTED BIRTH RATES

Year	Total population (P) (thousands)	Weighted sum of women (W) (thousands)	Ratio of (W) to (P)	Number of births	Birth rate	
					Crude	Sex-age adjusted
1938.....	6,297	6,776	1.076	93,946	14.9	13.9
1939.....	6,326	6,782	1.072	97,380	15.4	14.4
1940.....	6,356	6,812	1.072	95,778	15.1	14.1
1941.....	6,389	6,852	1.072	99,727	15.6	14.6
1942.....	6,432	6,857	1.066	113,961	17.7	16.6
1943.....	6,491	6,844	1.054	125,392	19.3	18.3
1944.....	6,560	6,827	1.041	134,991	20.6	19.8
1945.....	6,636	6,804	1.025	135,373	20.4	19.9
1946.....	6,719	6,783	1.010	132,597	19.7	19.5
1947.....	6,803	6,768	0.995	128,779	18.9	19.0
1948.....	6,883	6,736	0.979	126,683	18.4	18.8
1949.....	6,956	6,690	0.962	121,272	17.4	18.1
1950.....	7,017	6,637	0.946	115,414	16.4	17.4
1951.....	7,071	6,595	0.933	110,168	15.6	16.7
1952.....	7,125	6,545	0.919	110,088[b]	15.5	16.8
1953.....	7,192	6,446	0.896	110,105[b]	15.3	17.1
1954.....	7,213	...	(0.875)[a]	105,396[b]	14.6	16.7

[a] Estimated by extrapolation of the time series.
[b] Provisional figures.

Figure I. Fertility trend of Sweden, 1938-1954, as described by crude and by sex-age adjusted birth rates



as the proportion of married persons in the population, duration of marriage, and number of children born previously per woman, as well as by important non-demographic factors. Such factors may or may not require to be taken into account in a particular situation. Where important, they should be considered and, provided the requisite data exist, a more pertinent fertility measure than the one derived here should be employed. The description of more elaborate fertility measurements, however, is beyond the scope of the present manual.

B. Estimation of current or recent level of fertility

260. The determination of the current level of a birth rate raises a problem of interpretation. Birth rates, like other time series, may vary in accordance with trend and cyclical movements, but are also affected by short-period fluctuations. The position of the rate on its trend, at a given moment of time, is determined after abstraction of short-term and cyclical fluctuations. Short-term variations are usually eliminated by taking a five-year average around a central date. But if cyclical variations or changes due to some unusual circumstances have occurred in a five-year period, some other method may have to be used. Interpretation of the trend itself will be considered further on in this chapter, in connexion with assumptions of future trend.

1. *Estimates based on presumably reliable statistics of births*

261. Unless there are good reasons to do otherwise, it will usually be convenient and advantageous to begin by establishing the current level of the sex-age adjusted birth rate, as explained in the preceding pages. An example of the computation of this rate was given above, utilizing the statistics of Cyprus for the year 1950, but for the purpose of a population projection, the rate for a single year does not provide a firm enough basis. In

TABLE 27. COMPUTATION OF SEX-AGE ADJUSTED BIRTH RATE FOR ICELAND, 1946–1950, FROM DATA OF CENSUSES OF DECEMBER 1940 AND DECEMBER 1950

Age in years	Female population 1940	1950	1946–50 [a]	Weight	Product	Estimated annual number of births 1946–50	Sex-age adjusted birth rate
15–19	5,690	5,969	5,899	1	5,899	...	...
20–24	5,097	6,058	5,818	7	40,726	...	...
25–29	4,677	5,416	5,231	7	36,617	...	...
30–34	4,178	4,873	4,699	6	28,194	...	...
35–39	3,868	4,558	4,386	4	17,544	...	...
40–44	3,670	4,057	3,960	1	3,960	...	...
TOTAL	...	...	...		132,940	3,801	28.59

[a] The mid-point of the 1946–50 period is 7½ years after the 1940 census and 2½ years before the 1950 census. Interpolation is made in the ratio of three to one.

the years from 1948 to 1952, the following numbers of births were reported in Cyprus: 15,078, 13,234, 14,517, 14,403, and 13,358, or an annual average of 14,118. It is justifiable to assume in all but the most unusual situations that the weighted sum of women for the average of a five-year period is very nearly equal to that at the central date of the period. The average of 14,118 births is therefore divided by the weighted sum of 469,037 women in mid-1950, and the sex-age adjusted birth rate is found to be 29.21 for 1948-1952.

2. *Estimates by reverse survival of one cohort of children*

262. Where satisfactory statistics of births are not available, or where there are grounds to suspect incompleteness of birth registration, the recent level of fertility can be estimated from the number of children enumerated in a recent census, by calculating the probable number of births from which this number of children survived. This is accomplished by a reversal of the procedure of survival computations used for a population projection; the given number of children is divided by the appropriate survival ratio (P_x) to obtain the estimated number of births.

263. For example, it is assumed that the numbers of women of various ages and the number of children 0-4 years old in Iceland in 1940 and 1950, as given in table 20, are known to be accurate figures but that no statistics of births are available. The mortality levels have already been estimated, and the values of P_b (survival ratio from birth to ages 0-4) referred to level 95. It is desired to estimate the sex-age adjusted birth rate for 1946-1950. The mean numbers of women of childbearing ages in the 1946-1950 period can be estimated by interpolation, in the ratio of three to one, from the figures for 1940 and 1950. It remains to estimate the number of births.

264. In 1950 there were 9,466 males and 8,813 females aged 0-4. The survival ratios (P_b) at level 95, according to appendix table V, are 0.9580 for males and 0.9660 for females. By division, it is estimated that 9,881 males and 9,123 females, or a total of 19,004 children, were born during 1946-1950;[46] that is, an annual average of 3,801 births. The calculation of the adjusted birth rate is then carried out as shown in table 27.

265. The estimated sex-age adjusted birth rate of 28.59 per 1,000, obtained by this method, may be compared with the average crude birth rate shown by the birth registration statistics for those five years, which amounted to 27.6 per 1,000, as related to a total population of 137,000 in mid-year 1948. The difference between the two rates is mainly due to the fact that the population structure slightly favoured a low birth rate.

3. *Estimates by reverse survival of women and two cohorts of children*

266. The conditions assumed for the preceding example are not often realized. Where statistics of the population are accurate, births and deaths are usually also recorded with at least a fair degree of accuracy, so that this procedure is unnecessary. The procedure is

TABLE 28. ESTIMATE OF NUMBERS OF BIRTHS IN THAILAND, 1942–47 AND 1937–42, BY "REVERSE SURVIVAL" OF TWO COHORTS OF CHILDREN ENUMERATED IN THE 1947 CENSUS

		Males	Females
A.	*Cohort born 23 May 1942 to 22 May 1947 (aged 0–4 in 1947)*		
1.	Survivors enumerated 23 May 1947	1,328,574	1,315,780
2.	Mortality level for P_b, 1942–47	45	45
3.	Estimated survival ratio (P_b), 1942–47	0.7950	0.8135
4.	Estimated births, 1942–47 (item 1 divided by item 3)	1,671,162	1,617,431
B.	*Cohort born 22 May 1937 to 23 May 1942 (aged 5–9 in 1947)*		
5.	Survivors enumerated 23 May 1947	1,250,120	1,220,829
6.	Mortality level for P_{0-4}, 1942–47	45	45
7.	Estimated survival ratio (P_{0-4}), 1942–47	0.9198	0.9209
8.	Mortality level for P_b, 1937–42	40	40
9.	Estimated survival ratio (P_b), 1937–42	0.7789	0.7969
10.	Estimated births, 1937–42 (item 5 divided by the product of items 7 and 9)	1,744,925	1,663,560

[46] Actually, according to the official statistics, 18,935 births occurred during that period.

usually required where there are no reliable birth records and where the population data themselves are subject to appreciable error, especially as regards the enumeration of children 0-4. But, as has been argued in chapter II, enumeration of the 5-9 year age group is usually at least tolerably accurate, and probably more accurate than that of any other age group. The procedure of "reverse survival" must then be applied over a ten-year period, to estimate the number of births of which the enumerated children aged 5-9 years are the survivors.

267. This procedure is illustrated in tables 28, 29, and 30, by means of the statistics of Thailand in 1947 referred to in table 19. The mortality levels which were assessed for 1947 are assumed to apply also to the 1942-1947 period. In 1937-1942, mortality is assumed to have been higher; the levels are accordingly reduced by five points, as shown in lines 6 and 8 in table 28, and in columns 3 and 6 of table 29.

TABLE 29. ESTIMATE OF FEMALE POPULATION 15–44 YEARS OF AGE IN THAILAND, 1942 AND 1937, BY "REVERSE SURVIVAL" OF COHORTS ENUMERATED IN THE CENSUS OF 1947

Age in years	*Female population enumerated, May 1947*	*Survivorship, 1942–47*		*Estimated female population, May 1942*[a]	*Survivorship, 1937–42*		*Estimated female population, May 1937*[b]
		Mortality level	*Survival ratio (P_x)*		*Mortality level*	*Survival ratio (P_x)*	
15–19.....	979,613	55	0.9709	816,115	50	0.9671	687,122
20–24.....	792,366	50	0.9606	664,516	45	0.9555	627,550
25–29.....	638,334	45	0.9520	599,624	40	0.9456	547,007
30–34.....	570,842	45	0.9490	517,250	40	0.9419	460,528
35–39.....	490,870	45	0.9448	433,771	40	0.9372	391,382
40–44.....	409,827	45	0.9369	366,803	40	0.9290	301,956
45–49.....	343,658	45	0.9229	280,517			
50–54.....	258,889						

[a] Calculated by dividing the P_x value for the same age group into the enumerated female population, 1947, for the next older group.
[b] Calculated by dividing the P_x value for the same age group into the estimated female population, 1942, for the next older group.

268. The age groups of 1947 which must be considered comprise children of either sex aged less than 10 years and women aged 15 to 54 years. Numbers of the population living five years previously, when they were 5 years younger, are computed by dividing numbers living at the base date with the appropriate survival ratios. It is to be noted that the survival ratios are those of the preceding age group, since it is from those ages that the individuals enumerated at the base date survived. The number of children born in the preceding five-year period is similarly estimated by division with the survival ratio for births, P_b. These procedures are used twice. From the first set of computations, estimates are obtained of births during 1942-1947, children aged 0-4 years in 1942, and women 15-49 in 1942. Second, survival ratios for the 1937-1942 period are applied to these results, to obtain estimates of births in 1937-1942 and of women aged 15-44 in 1937.

269. By averaging the numbers of women of childbearing ages in 1947, 1942 and 1937, mean numbers of women of those ages are obtained for each of the two five-year periods (table 30). Multiplying these numbers with the weights and adding the products, and dividing the sum into one fifth of the estimated numbers of births for the two periods, one obtains the sex-age adjusted birth rates of 47.99 in 1937-1942 and 41.54 per 1,000 in 1942-1947. The latter rate, however, is probably under-estimated, since it is probable that children 0-4 were incompletely enumerated in the 1947 census. It is not unlikely that fertility in 1942-1947 was fully as high as in 1937-1942.

270. On the assumption that the birth rates in the two periods were actually the same, the extent of underenumeration of children 0-4 years old at the census can be estimated by taking the ratio of the sex-age adjusted birth rate as computed for 1937-1942 to that for 1942-1947. This ratio is 1.1553, which implies that there were about 115.53 children for every 100 enumerated. By applying this ratio to the enumerated numbers of children

TABLE 30. CALCULATION OF SEX-AGE ADJUSTED BIRTH RATES FOR THAILAND, 1932–37 AND 1942–47, ON THE BASIS OF ESTIMATES BY "INVERSE SURVIVAL" OF WOMEN AND TWO COHORTS OF CHILDREN ENUMERATED IN THE 1947 CENSUS

Age in years	*Weight*	*Estimated mean female population*[a]		*Estimated annual number of births*[b]		*Sex-age adjusted birth rate*	
		1937–42	*1942–47*	*1937–42*	*1942–47*	*1937–42*	*1942–47*
15–19....	1	751,618	897,864				
20–24....	7	646,033	728,441				
25–29....	7	573,316	618,979				
30–34....	6	488,889	544,046				
35–39....	4	412,576	462,321				
40–44....	1	334,380	388,315				
TOTAL				681,697	657,819	47.99	41.54
WEIGHTED SUM		14,342,845	15,661,035				

[a] Calculated by averaging, respectively, estimates for 1937 and 1942, and estimate for 1942 and 1947 census figure, for the same age group, as shown in table 29.
[b] Estimates from table 28, summed for the two sexes, and divided by 5 to obtain average annual numbers of births.

0-4 in 1947, it is estimated that there were 1,534,902 male and 1,520,121 female children of those ages, and that about 400,000 were omitted from the census count. If this is a correct estimate, the total population of Thailand was greater by at least 400,000 than the census figure. However, in view of the wide currency of the census figures, it is undesirable to substitute a different estimate of total population as of the date of the census, lest the users of the projections be misled by a comparison with the census figure. It is preferable, after substituting the revised figures for children aged 0-4 years, to "pro-rate" the entire age-distribution for each sex as of 1947 so that the total will agree with that of the census.

4. *Estimates by the method of stable populations*

271. Given a few statistics only, it is possible to estimate various features of a population with the use of "stable population" models. Owing to the rather close relationship of fertility to population age structure, fertility is one of the population characteristics which can be estimated comparatively well in such a fashion. The use of "stable" populations for estimating purposes will be discussed in another publication.

C. Estimation of probable future fertility trends

272. Judicious selection of realistic and plausible assumptions as to future fertility trends cannot be tied to any hard and fast rule, since no two situations are exactly alike in all respects. The assumptions must be based on reasonable judgement, derived from past observations and experience in apparently similar situations, taking all relevant conditions into account so far as possible. Since knowledge of the factors which influence human fertility is incomplete, the consideration of factors likely to be relevant is a matter of opinion.

273. The following discussion is intended to show how the results of a study of the past record of fertility trends in various parts of the world can be brought to bear on the formulation of assumptions concerning the future tendencies to be expected in a given situation. The examples of assumptions presented here are mainly illustrative and do not necessarily represent the most realistic assumptions that could be made in the situations mentioned.

274. The problem of forecasting fertility is especially important, both because of the substantial impact of this factor on the future growth and composition of the population, and because the trend is much more obscure than that of mortality. There is an almost universal tendency of mortality to decline because of the constant efforts to reduce the frequency of premature deaths, and consequently, some basic generalizations as to the probable future progress in longevity can be made with considerable assurance. Fertility, on the other hand, tends neither towards its possible maximum nor its possible minimum, but rather towards a level which represents a balance of conditions that affect it both in a positive and in a negative sense. This balance is an expression of the culture of a particular population; it varies from one population to another, and within the same population in the course of time. It is not possible to estimate very assuredly the extent to which this "normal" level is likely to be shifted as economic and social conditions, cultural values, and aspirations change. The historical observation of population trends under a great variety of conditions can, nevertheless, offer some suggestions as to what may be expected in a particular situation.

275. In a given situation, once the recent level and trend of fertility have been measured or estimated in the most relevant terms, three steps are required for a future projection. First, from these measurements, the nature of the past trend needs to be interpreted. Next, this trend should be compared with trends observed elsewhere or on previous occasions. Finally, by analogy with other observed situations, inferences should be made as to a plausible course of future development.

1. *Interpretation of past trend*

276. Interpretation of the past trend in fertility requires a series of relevant figures covering a sufficiently long period of the past. Historical series of fertility data are lacking for very many countries, but in many of those countries fertility is high and has probably not changed very greatly for a long period of time. Whether this can reasonably be assumed to be true in a particular instance can be tested, if data on age composition of the population are available, by comparing these data with the age structure of a stable population. If fertility has been approximately constant, even though mortality may have changed, the population should resemble one of the stable populations tabulated in the appendix. Any significant deviation from the pattern of a stable population, which cannot be otherwise accounted for, implies that fertility has varied in the past and may provide the basis for an inference concerning the changes which have taken place.

277. Constancy of past crude birth rates is generally a sufficient indication that sex-age adjusted rates, if they could be computed, would also be fairly constant. It should be noted, however, that the accuracy of the birth statistics must be examined before a sound evaluation of the trend can be made. Progressive improvement in the completeness of birth registration has the effect of raising the birth rate even though fertility remains unchanged. Where the accuracy of the vital statistics is in doubt, it is advisable, if only for a rough check, to estimate the sex-age adjusted birth rate for one or more past dates by means of census data and the "reverse survival" method.

278. A regular rise or decline in fertility over a long period is more accurately portrayed by sex-age adjusted birth rates than by crude birth rates because the change of fertility affects the proportion of the population at childbearing ages in such a way as to retard somewhat the rise or fall of the crude birth rate. It is not necessary, however, to compute the sex-age adjusted birth rate for every year of a long past period; in fact, this is not possible where statistics on sex-age structure of the population are not available annually. Average rates may be computed around the dates of several censuses. If the intervals between census dates are too long, the ratio of total population to the weighted sum of women can then be interpolated for intermediate dates and crude birth rates for these dates can be adjusted by dividing them by this ratio.

279. Special problems are encountered where past changes in fertility have been irregular. Year-to-year fluctuations in birth rates do not complicate interpreta-

tion of the trend, since they are almost entirely eliminated by five-year averages. A difficulty arises in the case of "cyclical" changes in fertility over periods of perhaps ten or fifteen years. Such variations may occur in response to changes in economic circumstances or social attitudes, or as a result of war and subsequent demobilization. They usually involve changes in the timing of marriages and births, which may have cumulative effects on the birth rate. Indications that this has been happening may be found in statistics on marriages by age, and on births by age of mother, duration of marriage, and order of birth. A "cyclical" change may be followed by a new and different secular trend. This problem may also affect the interpretation of the current level of fertility; if a "cyclical" variation is in progress, the current rate is not representative of a long-term trend. Where there are indications of a "cyclical" variation, any effort to extrapolate trends of fertility into the future must be undertaken with special caution, preferably with the help of refined fertility measures.

2. *The history of fertility trends in different parts of the world as a guide to assumptions regarding future trends in particular cases*

280. Certain generalizations can be made concerning the history of fertility changes in different parts of the world, which are often helpful in arriving at plausible assumptions concerning the future trend of fertility in certain types of situations. It is useful for this purpose to distinguish situations of high fertility (birth rates of 40 per 1,000 or more), moderately high fertility (birth rates of 30 to 40), moderately low fertility (birth rates of 20 to 30), and low fertility (birth rates of less than 20).

281. High fertility has normally been marked by a certain constancy. In countries of very high fertility, fluctuations of the birth rate have been observed which could be attributed to the temporary effects of epidemic diseases or other factors, but the trend over long periods has generally been either level or slightly upward or downward. Where there has been a considerable amount of sterility due to disease, a slight upward trend may occur, as a result of improving conditions of health, and it is possible that a progressive improvement of economic conditions may have a similar effect in some circumstances. A gradual decline from very high fertility levels may be produced by changing attitudes and practices with respect to the age at marriage and the number of children that parents desire. Where such changes have been observed in the past, the new attitudes and practices have been adopted first by small groups of the population and gradually diffused among wider and wider elements, so that the general level of fertility declined only gradually at first but with growing momentum when substantially lower levels were reached. There have been few, if any, examples in modern times of a rapid decline of fertility from a very high level.

282. Moderately high fertility, with birth rates between 30 and 40 per 1,000, has often proved to be only a phase in the transition from very high to lower fertility. Sometimes it has been the result of very high fertility being maintained by one segment of the population while another segment was adopting low-fertility attitudes and practices. However, some populations have exhibited fertility at a constant, moderately high level over long periods of time. This may be the result of such factors as late marriage, unstable marital unions, polygamy, frequent and prolonged separation of couples, sexual taboos, or unusually long breast-feeding of infants. In such circumstances, there is the possibility of a substantial increase of fertility resulting from the breakdown of the customs or removal of the other conditions which have been responsible for keeping it at a moderately low level. On the other hand, there is also the possibility of a transition to lower fertility, due to the adoption over a period of time, of changed attitudes and practices relating to marriage and procreation. The situation of moderately high fertility is therefore likely, in general, to be somewhat less stable than that of very high fertility.

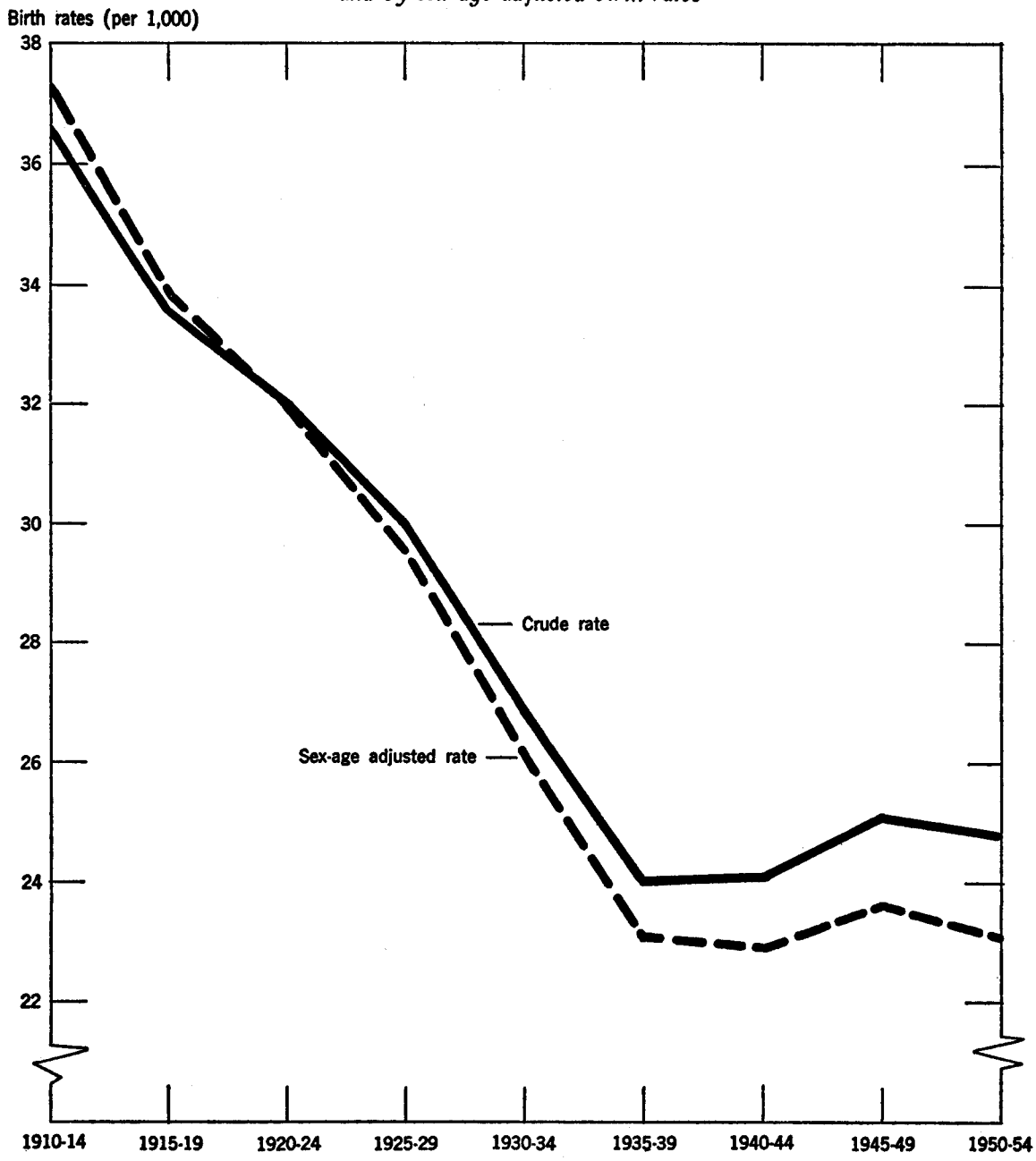
283. Moderately low fertility (birth rates of 20 to 30) has been observed in many European countries and countries of essentially European culture overseas, during recent times. In some cases, this may have been only a stage in the transition to low fertility, but in other cases it appears that moderately low fertility has been maintained over a considerable period of time, though often with considerable fluctuations. The interpretation of the long-term trends for those countries where fertility has been at such levels during the last twenty years is complicated by important cyclical variations. It seems that the fertility of a population in which most families have accepted the principle of regulating births and have adopted relatively efficient methods of doing so, is subject to relatively strong influences from cyclical changes in economic conditions and other circumstances.

284. Perhaps the clearest example of a fertility having settled at a moderately low level, after a long, steady decline, is afforded by the case of Argentina. Unlike most other populations of European origin, that of Argentina has been relatively little affected by the repercussions of war and economic depression upon the birth rate. The birth rate of Argentina declined continuously until 1933, but since then has been remarkably steady on a moderately low level (see figure II). Birth rates at a similar level have also been recorded since 1948 in other countries of low population density, high urbanization, and advanced industrialization, including Canada, the United States, Australia and New Zealand, but in these cases there were large fluctuations during the 1930's and 1940's, so that it is difficult to say whether the current rates should be considered as conforming to a long-term trend.

285. In the case of those countries where fertility has only recently declined from a moderately high to a moderately low level (for example, Japan, some of the Eastern European countries, and apparently the Soviet Union), it remains to be seen whether the trend will continue until fertility is stabilized at a considerably lower level, or whether the present moderately low level will persist. There are no cases on record of reliable statistics showing a sustained rise of fertility to moderately high or very high levels, once a moderately low level has been reached.

286. Low fertility (birth rates below 20) was observed in many countries in the European cultural sphere during the early 1930's, but subsequent developments have shown that the birth rates of that period were abnormally low, representing a depression below the

Figure II. Fertility trend of Argentina, 1910-1954, as described by crude and by sex-age adjusted birth rates



long-term fertility trend due to temporary postponement of marriages and births. In many of these same countries, an abnormal increase of births was registered during the late 1940's, followed by a drop to low fertility levels once more. The cyclical variation is quite apparent in the figures for Sweden (see figure I, chapter V), which was not a belligerent in World War II. It is not so clear in the figures for other countries where the effects of the war and subsequent demobilization apparently modified the course of the birth rates. The historical series of rates for this group of countries does not afford any definite basis for determining whether the current low fertility level should be accepted as conforming to the long-term trend or regarded as a temporary depression below it. A similar uncertainty attaches to the interpretation of the figures for countries like Italy and Greece, where fertility has reached a low level during the last few years only. The low rates in these cases might represent the effect of a cyclical variation superimposed upon the long-term downward trend.

287. The generalizations presented above evidently do not provide a sufficient basis for any formulae from which suitable assumptions as to future fertility trends in particular countries could be mechanically derived. They can only serve as a background against which each situation must be examined with due regard to all its relevant features. With these reservations, the following summary is offered.

288. Where fertility is very high with no clear indication of any incipient decline, it may well remain equally high for a long period in the future, and the possibility

of a moderate rise may also have to be considered. A decline may commence either in the near or more distant future; if it occurs, it is likely to be slow at first but to continue, perhaps with growing momentum, for a long period.

289. Similar considerations apply where fertility has been constant at a moderately high level, except that if a rise occurs it can be more substantial, whereas a decline, if it sets in, may perhaps be more rapid in the initial stages, inasmuch as the same factors which previously held fertility at a moderate level may now contribute to its decline.

290. Where fertility has definitely entered a decline but is still at least moderately high, it is plausible that the decline will continue over a long period, at least until a moderately low level is reached. The downward trend may, however, be accelerated if it is now slow, or retarded if it is now rapid.

291. A condition of moderately low fertility may either be stable or a prelude to lower fertility; the latter possibility is perhaps somewhat more likely if the moderately low level has only recently been achieved as a result of a long-continued decline, than if it has persisted for some time. It should be realized, however, that moderately low birth rates at a given time may be only the product of cyclical variations in a situation where distinctly lower fertility would be in accord with the long-term trend.

292. Very low fertility may likewise be a result of a cyclical depression of fertility below the long-term trend; in that event, a rise in the near future is evidently plausible. Although there is no very clear historical precedent for a sustained increase of fertility from a stable, very low position, this possibility requires consideration in areas where fertility has remained very low for a considerable period of time. The possibility of a further decrease also cannot be excluded, especially where the present low level is the result of a long-continued decline in the past. However, in such a situation a question can reasonably be raised as to how low fertility may reasonably be expected to fall in the future.

293. The fertility assumptions for the population projections made by the United Nations staff were formulated, in general, by interpreting considerations such as those stated above in the light of whatever information was at hand bearing on the special features of the case in question. In each case, the assumptions chosen were formulated in relatively simple terms; for example, where declining fertility was envisaged, the assumption of a constant reduction of the sex-age adjusted birth rate during each successive five-year period unless and until a certain reasonable minimum was reached. To map out any complex course of changes through which fertility will be presumed to pass in the future is seldom reasonable in view of the uncertainty which is inevitably attached to any assumption, even with respect to the general direction and tempo of change.

3. *The use of alternative assumptions as to future fertility*

294. In recognition of the fact that several rather diverse possibilities for the future often appear to be almost equally plausible, the United Nations projections were carried out for each country on three different fertility assumptions, corresponding to high, medium, and low rates of future population growth. Such a procedure is more appropriate with respect to fertility than to mortality or, as will be shown in chapter IX, to migration.

295. A population projection made on the basis of one fertility assumption only may produce an unwarranted impression of confidence in its results. Furthermore, it is less useful, as a guide in the formulation of social and economic policies and programmes, than one in which a reasonable range of future expectations is comprised.

296. Even though it is not possible to calculate the probability that any given assumption will be realized, the choice of alternatives should be guided by some consideration of their apparent likelihood. If one particular fertility trend seems more probable than others, this may be taken as a "medium" assumption. The calculations may then be carried through according to this assumption and others, considered somewhat less likely, which would yield higher and lower estimates for the future. It is useful to choose such a range of possibilities that the future course of events appears more likely to fall within than without that range. Such was the guiding principle of the choice of "high", "medium" and "low" fertility assumptions for the United Nations projections.

D. The example of Costa Rica: estimate of fertility level, assumptions as to future fertility trends

1. *Estimation of the current fertility level*

297. The record of crude birth rates obtained from the statistics of registered births in Costa Rica is confused by the fact that many births are registered only after a delay which may amount to a considerable number of years. Before 1948, the statistics were tabulated only according to the year of registration, regardless of the year in which the birth was reported to have occurred. For 1948 and subsequent years, two series of official birth rates have been published, one relating to the total number of births, per 1,000 population, registered in the given year and the other to the births reported as having occurred in that year. The latter series is officially estimated to represent only 75 to 80 per cent of the actual numbers of births occurring each year. The series are shown in table 31.

298. The rates according to year of registration for the period 1921 to 1950 (with the exception of the figure for 1947, which is apparently inflated by an unusually large number of late registrations) imply more or less constant fertility at a very high level. The rates according to year of birth for 1949 and 1950 imply a similar level when the official estimate of a 20 or 25 per cent deficiency of registration is taken into account.

299. The much higher level of the rates by year of registration for 1952, 1953, and 1954 is evidently due mainly to an increase in the number of delayed registrations. However, some increase of fertility after 1950 is suggested by the rates on the basis of year of occurrence of the birth. The rising trend of these rates might be only

TABLE 31. OFFICIAL SERIES OF CRUDE BIRTH RATES PER 1,000 POPULATION BASED ON TABULATION OF BIRTHS BY YEAR OF REGISTRATION AND BY YEAR OF BIRTH, FOR COSTA RICA, 1921–1954

Year	Rate according to year of registration[a]	Year	Rate according to year of registration[b]	Rate according to year of birth[a]
1921–24.....	43.4	1948	44.5[c]	32.8
1925–29.....	46.6	1949	44.2[c]	36.0
1930–34.....	45.7	1950	46.5	37.4
1935–39.....	45.0	1951	47.6	38.1
1940–44.....	44.9	1952	54.8	39.7
1945.....	46.8	1953	53.9	39.7
1946.....	45.0	1954	52.6	41.3
1947.....	57.0			

[a] Figures corresponding until 1934 and for 1946 and 1947 to the series presented in the United Nations *Demographic Yearbook, 1955*. Divergent series, based on earlier official reports, are presented in previous issues of the *Yearbook*. From 1935 to 1945 figures taken from *Anuario Estadístico 1951–52 de Costa Rica*. These figures are comparable to the others.

[b] Figures presented in the United Nations *Demographic Yearbook, 1954*.

[c] Corrected figures.

a reflection of increasing completeness or promptness of registration, or it might be due to an increase in the number or the fertility of marriages, caused in turn by improved economic conditions or other factors. The recorded crude marriage rates give some support to the latter interpretation:

Years	Annual average number of marriages per 1,000 population[a]
1921–24.....	6.2
1925–29.....	7.6
1930–34.....	6.1
1935–39.....	6.6
1940–44.....	6.0
1945–49.....	6.5
1950–54.....	7.8

[a] United Nations *Demographic Yearbook*, 1953 and 1955.

The statistics of marriages, however, may also be affected by under-registration. Furthermore, there are many consensual unions in Costa Rica, and an increase in the number of marriages therefore does not necessarily imply a corresponding increase in the whole number of unions being formed.[47] In short, the evidence of a possible increase in marriages or fertility after 1950 is inconclusive.

300. An estimate of the sex-age adjusted birth rate for the period 1948 to 1952 can be made from the 1950 census data on female population by age groups and the average annual number of births during that period according to the series of registration statistics by year of birth, plus an allowance for the births which escaped registration. The calculations are shown in table 32.

TABLE 32. CALCULATION OF ESTIMATED AVERAGE SEX-AGE ADJUSTED BIRTH RATE FOR COSTA RICA, 1948–1952, BASED ON BIRTH REGISTRATION STATISTICS

Age in years	Female population, 1950[a]	Weight	Product	Estimated average annual number of births, 1948–52[b]	Sex-age adjusted birth rate
15–19....	43,826	1	43,826	...	...
20–24....	39,386	7	275,702	...	...
25–29....	30,491	7	213,437	...	...
30–34....	23,705	6	142,230	...	...
35–39....	23,930	4	95,720	...	...
40–44....	18,074	1	18,074	...	...
TOTAL	...	...	788,989	37,000–39,500	46.9–50.6

[a] Unadjusted results of the 1950 census.

[b] Average of registered births according to year of occurrence, as given in United Nations *Demographic Yearbook, 1955*, plus estimates of unregistered births according to official statement that 75 to 80 per cent of births occurring each year are registered.

301. By means of the estimates of female population of childbearing ages in 1955 derived in chapter II (table 9), together with the 1950 census figures, the sex-age

[47] In the case of Costa Rica, it is not possible to use the census statistics as an additional source of information on possible changes in the numbers of marital unions. The tabulations of the 1950 census include data on marital status but those of the preceding census, taken in 1927, do not.

TABLE 33. CALCULATION OF ESTIMATED AVERAGE SEX-AGE ADJUSTED BIRTH RATE FOR COSTA RICA, 1950–1955, BASED ON BIRTH REGISTRATION STATISTICS

Age in years	Female population			Weight	Estimated average annual number of births, 1950–55[c]	Sex-age adjusted birth rate
	Enumerated, 1950[a]	Estimated, 1955[b]	Mean, 1950–55			
15–19.....	44,010	48,301	46,156	1	...	...
20–24.....	38,679	43,581	41,130	7	...	...
25–29.....	30,595	38,187	34,391	7	...	...
30–34.....	24,830	30,125	27,478	6	...	...
35–39.....	22,622	24,289	23,456	4	...	...
40–44.....	18,548	22,024	20,286	1	...	...
TOTAL	...	...	...	...	42,000–44,800	49.2–52.5
WEIGHTED SUM	...	...	853,781			

[a] "Smoothed" census figures, from table 9.

[b] From table 9.

[c] Average of registered births according to year of occurrence as given in United Nations *Demographic Yearbook, 1955*, plus estimates of unregistered births according to official statement that 75 to 80 per cent of births occurring each year are registered.

TABLE 34. ESTIMATES OF MORTALITY LEVELS AND SURVIVAL RATIOS FOR CHILDREN AND WOMEN IN COSTA RICA, 1945–50 AND 1940–45

Sex and age (x)	Mortality level, both sexes			Survival ratio (P_x)	
	1949–51	1945–50	1940–45	1945–50	1940–45
Values for P_b					
Males	67.5	65	60	0.8557	0.8406
Females				0.8739	0.8594
Values for P_{0-4}					
Males	67.5	65	...	0.9518	...
Females				0.9537	...
Values for P_x, females					
15–19	84	81.5	76.5	0.9873	0.9846
20–24	80	77.5	72.5	0.9823	0.9789
25–29	76.5	74	69	0.9785	0.9748
30–34	72.5	70	65	0.9735	0.9695
35–39	70	67.5	62.5	0.9690	0.9646
40–44	69	66.5	61.5	0.9628	0.9581
45–49	69	66.5	...	0.9518	...

adjusted birth rate can also be estimated for the period 1950-1955, using the registered number of births for the years 1950-1954 inclusive, with the same proportional allowance for under-registration. This calculation is presented in table 33.

302. For comparison with these estimates, sex-age adjusted birth rates can be estimated for the period 1945-1950 and 1940-1945, by "reverse survival" of the cohorts of children aged 0-4 and 5-9 and of women 20 to 54 years of age, as enumerated in the 1950 census. The mortality levels for 1945-1950 and 1940-1945 can be deduced from those evaluated for 1949-1951 and future periods in chapter IV, table 22. There is evidence that mortality declined substantially during the 1940's; hence the assumption of a change of 5 points in the mortality level every 5 years, which was used for estimating the future survival ratios, may also be applied to the period 1940-1950. The derivation of the estimated mortality levels and the corresponding values of P_x from appendix table V, for the sex-age groups involved in the computations, is shown in table 34. Tables 35, 36 and 37 show the computations of the estimated sex-age adjusted birth rates, by the same methods illustrated with the data for Thailand in tables 28, 31 and 30.

TABLE 35. ESTIMATE OF NUMBERS OF BIRTHS IN COSTA RICA, 1945–50 AND 1940–45, BY "REVERSE SURVIVAL" OF TWO COHORTS OF CHILDREN ENUMERATED IN THE 1950 CENSUS

	Males	Females
A. *Cohort born 23 May 1945 to 22 May 1950 (aged 0–4 in 1950)*		
1. Survivors enumerated, 22 May 1950	67,481	65,154
2. Estimated survival ratio (P_b), 1945–1950	0.8557	0.8739
3. Estimated births, 1945–1950	78,861	74,555
B. *Cohort born 23 May 1940 to 22 May 1945 (aged 5–9 in 1950)*		
4. Survivors enumerated, 22 May 1950	56,789	55,367
5. Estimated survival ratio (P_{0-4}), 1945–1950	0.9518	0.9537
6. Estimated survival ratio (P_b), 1940–1945	0.8406	0.8594
7. Estimated births, 1940–1945	70,979	67,553

TABLE 36. ESTIMATE OF FEMALE POPULATION OF COSTA RICA, 1945 AND 1940, BY "REVERSE SURVIVAL" OF COHORTS ENUMERATED IN THE CENSUS OF 1950

Age in years	Female population enumerated, May 1950	Survival ratio (P_x), 1945–50	Estimated female population, May 1945	Survival ratio (P_x), 1940–45	Estimated female population, May 1940
15–19	43,826	0.9873	39,893	0.9846	31,525
20–24	39,386	0.9823	31,040	0.9789	24,748
25–29	30,491	0.9785	24,226	0.9748	25,216
30–34	23,705	0.9735	24,581	0.9695	19,239
35–39	23,930	0.9690	18,652	0.9646	15,038
40–44	18,074	0.9628	14,506	0.9581	12,998
45–49	13,966	0.9518	12,453		
50–54	11,853				

303. We now have the following estimates of the sex-age adjusted birth rate:

49.2-52.5 for 1950-1955, according to the official vital statistics and the official estimate of 75 to 80 per cent completeness of registration;

46.9-50.6 on the same basis for 1948-1952;

42.25 for 1945-1950 according to the "reverse survival" estimates;

44.93 for 1940-1945 according to the "reverse survival" estimates.

304. The difference between the estimates based on the vital statistics for 1948-1952 and the estimate from the "reverse survival" computations for 1945-1950 could be reconciled with an hypothesis of unchanging fertility, on the assumption that only 83.5 to 90 per cent of the children aged 0-4 in 1950 were enumerated in the census. The assumption of at least a 10 per cent deficiency in the enumeration of this age group is not inconsistent with the general experience of census-taking in various countries with social conditions like those of Costa Rica.

305. The differences between the estimate by "reverse survival" for 1940-1945 and the estimates based on vital statistics for later periods imply either that fertility

TABLE 37. CALCULATION OF SEX-AGE ADJUSTED BIRTH RATES FOR COSTA RICA, 1940–45 AND 1945–50, ON THE BASIS OF ESTIMATES BY "REVERSE SURVIVAL" OF WOMEN AND TWO COHORTS OF CHILDREN ENUMERATED IN THE 1950 CENSUS

Age in years	Weight	Estimated mean female population		Estimated annual number of births		Sex-age adjusted birth rate	
		1940–45	1945–50	1940–45	1945–50	1940–45	1945–50
15–19	1	41,860	35,709				
20–24	7	35,213	27,894				
25–29	7	27,358	24,721				
30–34	6	24,143	21,910				
35–39	4	21,291	16,845				
40–44	1	16,290	13,752				
TOTAL	...	...	...	27,706	30,683	44.93	42.25
WEIGHTED SUM	...	726,169	616,606				

increased after 1940-1945 or that the official estimate of the degree of completeness of birth registration is under-stated. To be sure, the estimated rate for 1940-1945 might be somewhat too low because of incomplete enumeration of children aged 5-9 in the census or an excessively high estimate of the survival rates applicable to this cohort in 1940-1945 and 1945-1949, but errors from these sources are not likely to be very large. If fertility was actually constant throughout the period 1940 to 1955 at approximately the level indicated by the "reverse survival" estimate for 1940-1945, it follows that the proportion of births registered in 1948-1952 was about 84 per cent, and in 1950-1955 about 88 per cent, instead of the 75 to 80 per cent estimated by the Costa Rican authorities. Such proportions of completeness are not implausible, since the true proportion is presumably not exactly known to the authorities. On the other hand, a moderate increase of fertility between 1940-1945 and 1950-1955, sufficient to bring the sex-age adjusted rate near the lower end, at least, of the range of estimates based on the adjusted vital statistics, is also possible.

306. The United Nations projections for various countries where vital statistics are imperfect were based, as a rule, on estimates of current fertility levels derived from "reverse survival" computations applied to census data, rather than estimates from the vital statistics, unless there were definite reasons for preferring the latter basis. In the case of Costa Rica, the sex-age adjusted rate of 44.93 estimated by "reverse survival" for 1940-1945 is therefore accepted as representing the current fertility level for the sake of consistency with this general procedure, although the lower limits of the estimates derived from vital statistics appear equally plausible. The sex-age adjusted birth rate of 44.93 for 1940-1945 is presumed to have prevailed without any major change for some time in the past.

2. *Estimation of numbers of children aged 0-4 and 5-9 in 1955*

307. A preliminary estimate of the sex-age distribution of the Costa Rican population in 1955 is shown in table 9. This estimate is incomplete because it does not take account of incomplete enumeration of the age group 0-4 in the 1950 census, nor of births during 1950-1955.

308. A minimum estimate of the deficiency in enumeration of children 0-4 in 1950, on the assumption of a constant sex-age adjusted birth rate of 44.93 per 1,000 in 1940-1945 and 1945-1950 is represented by the difference between this rate and the figure of 42.25 obtained by "reverse-survival" of the cohort aged 0-4 in 1950 — that is, a difference of 5.7 per cent of the higher figure. A larger percentage of omissions from the enumeration would be obtained by accepting the birth rate derived from vital statistics. The statistics do not suggest that completeness of enumeration differed markedly as between boys and girls. New estimates for numbers of each sex aged 0-4 years in 1950 are obtained by dividing the numbers enumerated by 0.943; that is, 71,560 males and 69,092 females aged 0-4 instead of 67,481 males and 65,154 females, as enumerated.

309. Assuming a constant sex-age adjusted birth rate of 44.93, births during 1950-1955 are estimated by multiplying this rate with the weighted sum of the mean estimates of female population aged 15-44 in the period 1950-1955, as shown in table 33. The resulting estimate of 38,360 births annually corresponds to a total of 191,800 during the period from mid-year 1950 to mid-year 1955, which exceeds the registered total for the years 1950-1954, inclusive, according to the year-of-occurrence series, by 23,871, implying under-registration to the extent of approximately 12.5 per cent during this period.

TABLE 38. ESTIMATION OF NUMBERS OF SURVIVORS AGED 0–4 AND 5–9 IN COSTA RICA, 1955

	Males	Females
A. *Cohort born 1950–1955 (aged 0–4 in 1955)*		
1. Estimated births, 1950–1955	98,239	93,561
2. Mortality level for P_b, 1950–1955	70	70
3. Estimated survival ratio (P_b), 1950–1955	0.8703	0.8882
4. Estimated survivors, 1955	85,497	83,101
B. *Cohort born 1945–1950 (aged 5–9 in 1955)*		
5. Estimated survivors, 1950	71,560	69,092
6. Mortality level for (P_{0-4}), 1950–1955	70	70
7. Estimated survival ratio (P_{0-4}), 1950–1955	0.9584	0.9607
8. Estimated survivors, 1955	68,583	66,377

310. On the assumption of 105 male per 100 female births, it is estimated that there were 98,239 male and 93,561 female births during the period 1950-1955. The numbers of survivors aged 0-4 and 5-9 in 1955 are then computed as shown in table 38.

311. The estimates of the Costa Rican population by sex and age groups for 1955 now remain to be brought into conformity with the official estimate of total population for that year. With the new estimates for age groups 0-4 and 5-9 derived in table 38, the provisional estimates made, up to this point, add to a total of 948,924, whereas the official estimate of total population, as of mid-year 1955, amounts to 951,093. The figures for the various sex-age groups are pro-rated to the latter total as shown in table 39.

TABLE 39. FINAL ESTIMATE OF POPULATION OF COSTA RICA, MID-YEAR 1955, BY SEX AND AGE, AS BASIS FOR THE POPULATION PROJECTION

Age in years	Provisional estimate [a]		Final estimate [b]	
	Males	Females	Males	Females
All ages.....	474,559	474,365	475,644	475,449
0–4.....	85,497	83,101	85,692	83,291
5–9.....	68,583	66,377	68,740	66,529
10–14.....	56,195	54,865	56,323	54,990
15–19.....	48,450	48,301	48,561	48,411
20–24.....	41,325	43,581	41,419	43,681
25–29.....	35,734	38,187	35,816	38,274
30–34.....	28,867	30,125	28,933	30,194
35–39.....	23,767	24,289	23,821	24,345
40–44.....	21,627	22,024	21,676	22,074
45–49.....	17,872	18,012	17,913	18,053
50–54.....	13,864	13,662	13,896	13,693
55–59.....	10,815	10,629	10,840	10,653
60–64.....	7,888	7,748	7,906	7,766
65–69.....	5,975	5,769	5,989	5,782
70–74.....	4,057	3,822	4,066	3,831
75–79.....	2,200	2,135	2,205	2,140
80–84.....	1,097	1,031	1,100	1,033
85 and over....	746	707	748	709

[a] Ages 10 and over according to table 9; ages 0–4 and 5–9 according to table 38.
[b] Pro-rated to total of 951,093.

3. *Assumption as to future fertility trend*

312. For the projection of the population of Costa Rica, beginning with the year 1950, which was included in the United Nations report, *The Population of Central America (including Mexico), 1950-1980*, the following assumptions as to fertility were made:

"High": Calculated rate, 1940-1945, remaining constant;

"Medium": Rate decreasing after 1950 by 5 per cent each quinquennium;

"Low": Rate decreasing after 1950 by 10 per cent each quinquennium.

These assumptions were formulated largely with a view to achieving comparability of results for the entire group of countries composing the region.

313. For a projection beginning in 1955 and taking into account the newly available statistics of registered births by year of occurrence for 1950-1954, it appears advisable to include an assumption of higher fertility in view of the upward trend of the recorded birth rates in the last years. As a "high" assumption therefore the future maintenance of an age-sex adjusted birth rate of about 50 per 1,000 is assumed, corresponding to the general level of the rates calculated from adjusted vital statistics for the period since 1948.

314. As a "medium" assumption, it is assumed that the rate of 44.93 per 1,000 calculated for 1940-1945 by reverse survival of age group 5-9 in the 1950 census, will be maintained from 1955 to 1975. Birth rates have been remarkably constant over a long period of the past. Contacts with areas of lower fertility are comparatively slight. Severe population pressure, forcing a decrease in fertility, will not necessarily arise in the near future.

315. Nevertheless, the possibility of a fertility decrease should not be disregarded. Social changes connected with urbanization, industrialization, and increased education may tend to modify attitudes towards the raising of families in this direction. A gradual decline, such as by 5 per cent of the last previous value in every five-year period, is possible. This is treated as the "low" assumption.

316. It will be understood that this assessment is highly tentative. Greater familiarity with conditions in the country might provide a basis for more realistic assumptions. The present assumptions result in the following future sex-age adjusted birth rates:

	1955–60	1960–65	1965–70	1970–75
"High"....	50.00	50.00	50.00	50.00
"Medium".	44.93	44.93	44.93	44.93
"Low"....	43.81 [a]	41.62 [b]	39.54 [b]	37.56 [b]

[a] 2½ per cent decline from 44.93, assumed up to 1960.
[b] 5 per cent decline from value for last previous quinquennium.

VI. COMPUTATION OF THE POPULATION PROJECTION: THE EXAMPLE OF COSTA RICA

317. The computations for the population projection begin with the base estimate of population by sex-age groups for the starting date and proceed by successive multiplication of each cohort by the appropriate survival ratios, survivors of future births being added in. These calculations can be conveniently carried out with worksheets of the type illustrated with the figures for Costa Rica in tables 40 and 41. The first worksheet consists of alternating columns for the numbers of individuals in the various sex-age groups at each date and the survival ratios for the interval between that date and the next. The other worksheet, illustrated by table 41, is used to compute the future numbers of births, on the given assumptions as to future trends of the sex-age adjusted birth rate, from the estimated future numbers of women of childbearing ages.

318. The method of calculation is explained below with the Costa Rican figures as an illustration, under each of the three chosen hypotheses with respect to future fertility.